PROCEDURES
FOR
THE DIVISION OF THE WATERS OF THE ST. MARY AND MILK RIVERS

prepared by

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Helena, Montana

and

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1.0 INTRODUCTION

The division of the waters of the St. Mary River and Milk River, including its tributaries, is governed by the Boundary Waters Treaty of 1909 which specifies the proportion of the natural flow to which each country is entitled. The subsequent Order of the International Joint Commission (IJC) dated October 4, 1921 gives general procedural guidelines for determining natural flow.

The natural flow computations are done on an interim basis to provide near real-time information for water management decisions to ensure that each country receives its share of the natural flow. In order to provide timely information it is necessary to use preliminary data including approximations, therefore, the natural flow computations are redone at year-end when all final data are available. The annual computations represent a final account of the division and are included in the annual report to the IJC. The procedures, assumptions and approximations used in determining the natural flow evolved with time but were never documented until, at the January, 1975 meeting of the Field Representatives, it was decided to document the methods then used to compute the natural flow. Since then, the documentation has been continually refined and updated to reflect new or modified procedures.

The intent of this report is to:
1. Document the procedures and assumptions used in determining natural flow.
2. Document the reasoning for certain procedures or assumptions.
3. Act as a user's manual for computing the natural flow on an interim and annual basis.

This Procedures manual is organized into main sections dealing with the St. Mary River, Milk River, and the Eastern Tributaries of the Milk River. The appendices contain maps, schematics, blank computation forms, and mailing lists for the interim and final reports. A companion document to this manual is the Procedures Guide for International Gauging Stations. This guide contains information on designation and operation of international gauging stations and the full text of the 1909 Boundary Waters Treaty and the 1921 Order of the International Joint Commission. It is suggested that Water Resources Branch hydrometric technicians and technologists also refer to Lesson Package No. 17, Volume 3 of the Hydrometric Technician Career Development Program.

2. DEFINITIONS

DCP - Data Collection Platform (for satellite transmission of hydrometric information)

Deficit - a deficit has occurred if, at the end of a division period, the terms of the Treaty have not been met at a specific division point, or if a discharge criterion has not been met.

Diversion - a man-made transfer of water from a stream for use at some other location.

IJC - the International Joint Commission.

IJC Report - the annual report to the IJC on the Division of the Waters of the St. Mary and Milk rivers.

Natural Flow - the quantity of water which would naturally flow in any watercourse had the flow not been affected by man-made features.

Order - the October 4, 1921 Order of the IJC.

PFRA - the Prairie Farm Rehabilitation Administration.

Sask Water - the Saskatchewan Water Corporation.

Treaty - the Boundary Waters Treaty of 1909.

USGS - the United States Geological Survey, Department of the Interior.

WRB - the Water Resources Branch, Inland Waters Directorate, Environment Canada.

3. BACKGROUND

The St. Mary River rises in northwestern Montana on the eastern slopes of the Rocky Mountains and flows north across the International Boundary into Alberta, emptying into the Oldman River near Lethbridge. The St. Mary River has a fairly regular and dependable flow during the summer irrigation period because of its source in the high elevation snow fields and glaciers of Glacier National Park. Winter flows are sustained by a ground water base flow.

The Milk River rises in the foothills of the eastern slope of the Rocky Mountains in Montana, flows northeasterly across the International Boundary into Alberta and, turning eastward, roughly parallels the boundary for about 350 river kilometres, re-crosses the International Boundary into Montana and empties into the Missouri River. The river flow is dependant on spring snowmelt and rainfall in the foothills and is thus less regular and dependable than the St. Mary River as a source of water.

A map of the drainage basins of the St. Mary and Milk rivers is in Appendix B.

When early development of agriculture extended into the semi-arid areas of Western Canada and the United States, it was soon evident that to be successful, irrigation would be essential. The Governments of both countries undertook to determine the water supplies available and the lands upon which they could be economically utilized.

The following is a brief chronology of events from the late 1800s and early 1900s related to the development of the division of the St. Mary and Milk rivers:

YEAR

1891 Colonel E.S. Nettleton, Chief Engineer, U.S. Department of Agriculture, reported on a reconnaissance investigation for a proposed canal to divert a part of the waters of the St. Mary River to the Milk River for irrigation in eastern Montana.

1893 Canada, by an Act of Parliament, incorporated the Alberta Irrigation Company and empowered the Company to engage in irrigation and to purchase or sell lands south of the fiftieth parallel of latitude in Alberta.

1894 The first diversion from the Milk River for irrigation purposes occurred at the Fort Belknap Canal near Harlem, Montana.

The Fourth Annual Irrigation Congress passed a motion urging the appointment of a joint Canada-USA commission to investigate and report upon International waterways affecting irrigation interests in both countries but no action followed.

1895 A survey in Canada showed the feasibility of irrigating a large tract of southern Alberta land by diverting water from the St. Mary River near the International Boundary.

1898 Construction work commenced on the southern Alberta irrigation project.

1900 The United States Reclamation Service determined that a diversion canal from the St. Mary River could be routed across the divide to the headwaters of the Milk River which would allow water to flow through Canada to the lower Milk River valley for irrigation.

1901 Canada, concerned over the possible loss of St. Mary River water due to the U.S.A. diversion canal, initiated surveys to determine the feasibility of diverting water from the Milk River for irrigation use.

1903 Following negotiations between the United States and Great Britain, the International Waterways Commission was appointed to investigate and report upon the conditions and uses of the water adjacent to the boundary between the United States and Canada. The question of the use of the waters of the St. Mary and Milk rivers was brought before the Commission but no action could be taken as Congress had limited the jurisdiction of the United States section of the Commission to waters whose natural outlet was the St. Lawrence River.

1904 The first section of the Canadian Milk River Canal was completed. The diversion alarmed United States irrigators who prompted the United States Government to protest the Canadian Milk River Canal.

1905 Canada invited the United States to suggest a plan for the settlement of the St. Mary-Milk River dispute.

1906 The United States Reclamation Service commenced construction on the diversion canal to divert water from the St. Mary River to the Milk River in Montana.

1907 The United States submitted its proposals for resolving the St. Mary River dispute; however, the International Waterways Commission had already begun to draft a treaty between Great Britain and the United States. The draft treaty covered the matter of the use of boundary waters in general between the United States and Canada and proposed the establishment of a joint commission to administer the treaty.

1909 The Boundary Waters Treaty was signed and Article VI therein expressly provided for the handling of the St. Mary - Milk rivers problem; the measurement and division of

> the waters was to be under the direction of the International Joint Commission (IJC) which was established by the Treaty.

The Treaty did not specify the method of measurement or division of the waters and the controversy that erupted over this question was almost as intense as the one which led to the negotiation of the Treaty. The IJC held a number of public hearings to settle the arguments and on October 4, 1921 issued an order on the method of measurement and division. This Order is still in effect although the actual computations procedures have evolved through a process of co-operative consultation between the United States Geological Survey (USGS) and the Water Resources Branch (WRB), Environment Canada.

Three of the eastern tributaries of the Milk River have sufficient current usage to require a formal division. These tributaries: Frenchman River, Battle Creek and Lodge Creek, rise in the Cypress Hills area of southeastern Alberta and southwestern Saskatchewan and flow in a southeasterly direction to join with the Milk River in Montana. Division of the water of these tributaries began in 1937 in the Frenchman River basin, 1957 in the Battle Creek basin and 1961 in the Lodge Creek basin. The remaining major tributaries: Woodpile, East Fork Battle, Lyons, Whitewater, Rock, and McEachern Creeks do not as yet have sufficient usage in Canada to warrant a division of flow.

4.0 ST. MARY RIVER

4.1 INTRODUCTION

The waters of the St. Mary River are divided in accordance with the Order of the IJC dated October 4, 1921. In general terms, Rule I states that during the irrigation season (April 1 to October 31), Canada shall be entitled to three-fourths of the natural flow at the International Boundary when the natural flow is 666 cubic feet per second (cfs) or less and flows in excess of 666 cfs (18.9 m^3/s) shall be divided equally between the two countries. During the non-irrigation season the natural flow at the International Boundary shall be divided equally between the two countries.

To ensure that the Order is followed, provisional computations are made on a daily basis and interim reports are prepared twice monthly whenever diversion is being made to the St. Mary Canal. Generally, reports are not necessary during the remainder of the year when the only depletion by the United States is storage in Lake Sherburne. The mean annual discharge into this reservoir is only about one-quarter of the mean annual natural flow of the St. Mary River at the International Boundary.

Lake Sherburne, the only storage reservoir in the St. Mary River basin in the United States, is used to store a portion of the United States' share for diversion to the Milk River. This water, after passing through Canada, is utilized by the United States in the lower Milk River valley.

A schematic map (No. 2 in Appendix K) depicts the St. Mary River basin and shows the monitored points used in the natural flow computations.

In very general terms, the natural flow of the St. Mary River at the International Boundary is computed from the recorded discharge records for the St. Mary River at the International Boundary adjusted for storage or release at Lake Sherburne and the diversion into the St. Mary Canal.

4.2 PROCEDURE FOR DETERMINING NATURAL FLOW

4.2.1 Division Periods

During the irrigation season (April 1 to October 31) tentative computations are made twice-monthly (every 15 or 16 days) to determine natural flows, shares, and deliveries during the period. Similiar computations are made in March when the St. Mary Canal is flowing. The natural flow during the remainder of the non-irrigation season (November through February), is computed using form INT-3 for convenience. Semi-monthly natural flow computations are exchanged between WRB and USGS for checking as soon as possible. The summary sheet, INT-1 or computer equivalent, is sent to the agencies listed in section 4.6. Examples of all the water division computations and forms are shown in section 4.5.

4.2.2 Lake Sherburne Reservoir

4.2.2.1 Storage changes Any water that is stored in Lake Sherburne depletes the natural flow and is a charge against the United States. Conversely, any water released from Lake Sherburne augments the natural flow and is a credit for the United States. The amount of water stored or released on a given day is computed as the difference in reservoir contents between 00:00 hours and 24:00 hours.

Any storage or release that takes place at Lake Sherburne requires about one day to affect the flow at the International Boundary; therefore, a one-day lag is applied to the data for Lake Sherburne. For instance, a volume of water released from Lake Sherburne on the first day of the month would appear in the natural flow computations on the second day of the month.

4.2.2.2 Reservoir evaporation The net evaporation loss is fairly insignificant due to:

1. The reservoir has consistently cool surface conditions.
2. There was a small net increase in open water surface due to reservoir construction. The reservoir was originally two smaller lakes.
3. This is a main stem reservoir with short detention time.

Based on this, evaporation has not been included in the calculation of natural flow since 1983.

4.2.2.3 Reservoir contents computation Reservoir contents are computed using the midnight pen readings (adjusted for datum and pen corrections) from the chart record and the stage-capacity table. Wind and seiche effects are graphically eliminated from the pen trace when necessary, and the "smoothed trace" is used to compute the midnight readings.

When the lake level drops below a stage of about 34 ft., drawdown will affect the manometer orifice, which is attached to the upstream side of an old wooden crib-type weir about 500 ft upstream from the gauge. When this occurs, extrapolation of valid pen trace is necessary to estimate gauge heights, as even the outside gauges do not indicate true lake level. Fortunately, this happens very infrequently and only for short periods of time. The explanation is given here only to alert the unfamiliar hydrographer with the situation.

Manual computations are made using form INT-2, shown in section 4.5. It is important to keep in mind the limitations of the sensing and recording instruments on such a large body of water before applying minor corrections (<0.03 ft) to this record.

With the USGS PRIME computer system, the computer can be used to determine midnight contents and 24-hour changes once the correct midnight gauge height has been computed. Simply type the command "NFLO" (R INTL>NFLO) to engage the user-friendly natural flow programs. An example of Lake Sherburne monthly output is shown in section 4.5.

4.2.3 St. Mary Canal

The volume of diversion charged against the United States is gauged ten miles downstream from the canal intake. At this point, a double syphon transfers the flow from the left bank to the right bank of the St. Mary River. Any channel loss between the intake and the gauge is assumed to eventually return to the river channel and become part of the recorded flow at the International Boundary. Likewise, when the syphon valves are open, all canal flow returns to the river and any flow recorded at the gauge is revised to zero.

4.2.4 Natural Flow Computations

The natural flow of the St. Mary River at the International Boundary is defined as the flow which would have reached Canada had it not been for man-made hydrologic changes in the drainage basin. Because the United States has constructed Lake Sherburne and the St. Mary Canal, the effects of these features on the natural flow must be accounted for by computations.

The equation used to compute the natural flow of the St. Mary River is as follows:

Natural Flow at International Boundary = Total flow used by the U.S. (contents change in Lake Sherburne plus flow diverted into the St. Mary Canal) + Recorded flow at International Boundary

Manual computations are made on form INT-1.

With the USGS PRIME system, the computer can be used to compute natural flow and water division results. After entering "NFLO" and then selecting "ST. MARY", follow the prompts to edit data files, run a selected water division period, and print the table(s). An example of the output is shown in section 4.5.

In most years, the initial release from Lake Sherburne is made when Swiftcurrent Creek is full of ice and Lower St. Mary Lake is at its annual low level. Consequently, the water released takes four to five days to reach the boundary. When the amount of water released exceeds the recorded flow at the boundary, the computations indicate negative natural flow. The practice is to set these negative values to zero. The compromise here is that, technically, the negative values should be kept, but, realistically, the natural flow is some positive number.

4.3 WATER DIVISION

4.3.1 Shares

In accordance with the IJC Order of 1921, Canada is entitled to three-fourths and the United States one-fourth of the natural flow of the St. Mary River at the International Boundary during the irrigation season (April 1 to October 31) when the natural flow is 666 ft^3/s (18.9 m^3/s) or less. Flows in excess of that are divided equally between the two countries, as are flows during the non-irrigation season (November 1 to March 31).

When computations are done manually, the St. Mary River Natural Flow Division Table, originally prepared by O.H. Hoover in 1937, is used to determine shares up to 5,000 cfs during the irrigation season. If the computer is used to compute natural flow, shares are automatically generated from an internal division table.

4.3.2 Excess and Deficit Flows

The 1921 Order is not very explicit on the accounting procedure for excess or deficit flows in any given period. As a result, the following procedure has evolved: deficit flows carry over from one period to another, are cumulative, and must be made up by subsequent excess flows; excess flows do not carry over from one period to another, are not cumulative, and cannot be used to make up future deficits.

The 1921 Order was also lacking for a procedure to refund deficit flows. The practice has evolved to refund any deficit in the subsequent division period or at a time beneficial to both countries.

In 1991, an agreement was reached between the Accredited Officers to allow a deficit of up to 2,000 cfs-days (4 900 dam^3) to accumulate from March to May when the United States is usually transferring as much water as possible to the Milk River system. This deficit can be refunded with future surplus flows or balanced with Canadian deficits on the Milk River. See section 4.3.3 and Appendix B for details.

4.3.3 St. Mary and Milk Rivers Streamflow Transfer

In the dry 1980's, Canada frequently used more than its share of the Milk River flow in the summer months and was allowed to divert a portion of its share of the St. Mary River into the Milk River via the United States' St. Mary Canal. The procedure to allow this was dependent on the status of natural flow computations, phone calls, a series of letters, and anticipation of summer runoff conditions. In 1990, an attempt to formalize an interagency agreement to streamline the procedure only seemed to complicate the issue further.

In 1991, the Accredited Officers agreed that the greatest beneficial use of the waters of the St. Mary and Milk rivers could be achieved by simply allowing Canada to accumulate a deficit on the Milk River until the end of September. In exchange, the United States would be allowed to accumulate a deficit on the St. Mary River from March to May, during which time the United States is usually diverting as much water as possible into the Milk River system. Both deficits would be limited to 4 900 dam^3 (2,000 cfs-days), and would be made up with future surplus deliveries or a balance of deficits between the two river systems. The Letter of Intent is given in Appendix B.

4.4 PUBLICATION DATA FOR IJC REPORT

4.4.1 Computation Units

All original data in the St. Mary River basin are collected in Imperial (English) units of measure. Provisional computations and interim reports are also made in Imperial units. For the IJC Report, which has been published in SI (metric) units since 1979, the data files for Lake Sherburne, St. Mary Canal, and St. Mary River are converted to SI units, and then the natural flows, shares, and division are recomputed.

4.4.2 Tables 1 and 1A

Table 1 is a summary of water division data taken directly from the final monthly division tables, Table 6 in Appendix A of the IJC Report. Table 1A is the Imperial version of Table 1, and is simply the SI values in Table 1 multiplied by 0.8107.

4.4.3 Tables 6 and 7

These tables are fairly self-explanatory. Table 6 is the signed monthly SI water division sheets for the St. Mary River at the International Boundary. Table 7 is the historical summary of the St. Mary that needs to be updated each year using form INT-3. The average at the end of the summary is recomputed each year, with all but the current year. Both of these tables are part of Appendix A of the IJC Report.

4.5 COMPUTATION FORMS

On the following pages are copies of:

INT-1 - Natural flow and water division of St. Mary River
INT-2 - Daily summmary of contents for Lake Sherburne
INT-3 - Worksheet to compute annual summaries for IJC report

These blank forms are followed by examples of completed forms, as well as computerized versions of INT-1 and INT-2, designated as INT-1C and INT-2C.

INT-1 NATURAL FLOW AND WATER DIVISION OF ST. MARY RIVER AT INTERNATIONAL BOUNDARY

PROVISIONAL COMPUTATIONS IN CFS-DAYS FOR ________________________, 19____.

DAY	NET CHANGE IN LAKE SHERBURNE (1 DAY LAG)	DIVERTED BY ST. MARY CANAL	TOTAL USED BY UNITED STATES	ST. MARY RIVER AT INT. BDY.	NATURAL FLOW AT INT. BDY.	UNITED STATES SHARE	CANADIAN SHARE	FLOW IN EXCESS OF CANADIAN SHARE
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
1-15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
16-								
1-								

Computed by ________________ Date _______. Checked by ______________ Date ______.

INT-1

NATURAL FLOW AND WATER DIVISION OF ST. MARY RIVER AT INTERNATIONAL BOUNDARY

PROVISIONAL COMPUTATIONS IN CFS-DAYS FOR August, 1990.

DAY	NET CHANGE IN LAKE SHERBURNE (1 DAY LAG)	DIVERTED BY ST. MARY CANAL	TOTAL USED BY UNITED STATES	ST. MARY RIVER AT INT. BDY.	NATURAL FLOW AT INT. BDY.	UNITED STATES SHARE	CANADIAN SHARE	FLOW IN EXCESS OF CANADIAN SHARE
1	-155	617	462	860	1322	494	828	32
2	-103	615	512	816	1328	497	831	-15
3	-171	615	444	775	1219	443	776	-1
4	-120	612	492	734	1226	446	780	-46
5	-153	611	458	687	1145	406	739	-52
6	-238	611	373	674	1047	357	690	-16
7	-269	611	342	654	996	331	665	-11
8	-309	610	301	632	933	300	633	-1
9	-265	609	344	613	957	312	645	-32
10	-296	609	313	596	909	288	621	-25
11	-277	608	331	574	905	286	619	-45
12	-282	605	323	555	878	272	606	-51
13	-296	605	309	528	837	252	585	-57
14	-301	603	302	507	809	238	571	-64
15	-292	603	311	486	797	232	565	-79
1-15	-3527	9144	5617	9691	15308	5154	10154	-463
16	-337	604	267	521	788	227	561	-40
17	-360	603	243	524	767	217	550	-26
18	-404	603	199	521	720	193	527	-6
19	-370	603	233	512	745	206	539	-27
20	-361	604	243	550	793	230	563	-13
21	-306	603	297	535	832	249	583	-48
22	-373	603	230	524	754	210	544	-20
23	-355	602	247	509	756	211	545	-36
24	-317	603	286	506	792	229	563	-57
25	-441	603	162	505	667	167	500	5
26	-320	602	282	497	779	223	556	-59
27	-356	602	246	483	729	198	531	-48
28	-426	603	177	474	651	163	488	-14
29	-453	602	149	467	616	154	462	5
30	-477	603	126	459	585	146	439	20
31	-473	601	128	443	571	143	428	15
16-31	-6129	9644	3515	8030	11545	3166	8379	-349
1-31	-9656	18788	9132	17721	26853	8320	18533	-812

Computed by DAB **Date** 9/4/90. **Checked by** BIV **Date** 9/10/90

INT-2 LAKE SHERBURNE PROVISIONAL

AT SHERBURNE, MT

DAILY SUMMARY OF CONTENTS FOR THE MONTH OF ____________________, 19_____.

DAY	PEN READING AT 2400 HRS (FEET)	CORRECTIONS			GAGE HEIGHT AT 2400 HRS (FEET)	CONTENTS AT 2400 HRS (CFS-DAYS)	24-HR CHANGE IN CONTENTS (CFS-DAYS)	DAY
		(FEET)	(FEET)	(FEET)				
1								1
2								2
3								3
4								4
5								5
6								6
7								7
8								8
9								9
10								10
11								11
12								12
13								13
14								14
15								15
16								16
17								17
18								18
19								19
20								20
21								21
22								22
23								23
24								24
25								25
26								26
27								27
28								28
29								29
30								30
31								31

Computed by ________ **Date** ________. **Checked by** ________ **Date** ________.

INT-2 LAKE SHERBURNE PROVISIONAL

AT SHERBURNE, MT

DAILY SUMMARY OF CONTENTS FOR THE MONTH OF August, 1990.

DAY	PEN READING AT 2400 HRS (FEET)	CORRECTIONS pen (FEET)	datum (FEET)	(FEET)	GAGE HEIGHT AT 2400 HRS (FEET)	CONTENTS AT 2400 HRS (CFS-DAYS)	24-HR CHANGE IN CONTENTS (CFS-DAYS)	DAY
	87.78	.00			87.78	34020		
	87.60	.00			87.60	33865	-155	
1	87.48	.00			87.48	33762	-103	1
2	87.29	-.01			87.28	33591	-171	2
3	87.15	-.01			87.14	33471	-120	3
4	86.97	-.01			86.96	33318	-153	4
5	86.69	-.01			86.68	33080	-238	5
6	86.37	-.01			86.36	32811	-269	6
7	86.01	-.02			85.99	32502	-309	7
8	85.69	-.02			85.67	32237	-265	8
9	85.33	-.02			85.31	31941	-296	9
10	84.99	-.02			84.97	31664	-277	10
11	84.64	-.02			84.62	31382	-282	11
12	84.28	-.03			84.25	31086	-296	12
13	83.90	-.03			83.87	30785	-301	13
14	83.53	-.03			83.50	30493	-292	14
15	83.08	-.01			83.07	30156	-337	15
16	82.61	+.01/ .00			82.61	29796	-360	16
17	82.09	.00			82.09	29392	-404	17
18	81.60	+.01			81.61	29022	-370	18
19	81.13	+.01			81.14	28661	-361	19
20	80.72	+.02			80.74	28355	-306	20
21	80.23	+.02			80.25	27982	-373	21
22	79.76	+.02			79.78	27626	-356	22
23	79.33	+.03			79.36	27310	-316	23
24	78.72	+.03	+.02		78.77	26869	-441	24
25	78.28	+.04	+.02		78.34	26549	-320	25
26	77.80	+.04	+.02		77.86	26193	-356	26
27	77.22	+.04	+.02		77.28	25767	-426	27
28	76.59	+.05	+.02		76.77	25314	-453	28
29	75.93	+.05	+.02		76.00	24837	-477	29
30	75.26	+.06	+.02		75.34	24364	-473	30
31	74.67	+.06/ .00	+.02 .00		74.67	23890	-474	31

Computed by DAB Date 9/4/90. Checked by BIV Date 9/10/90.

INT-3

ST. MARY RIVER AT INTERNATIONAL BOUNDARY
WORKSHEET TO COMPUTE ANNUAL SUMMARIES FOR IJC REPORT
FOR THE PERIOD NOVEMBER ______ TO OCTOBER ______

*** LAKE SHERBURNE **

Dates	Gage height (at 2400 hrs)		Contents (cfs-days)		Contents (DAM3)
Feb. 27/28	__________		__________		
Oct. 30 (previous year)	__________	-	__________		
	Storage		__________	x 2.4466 =	__________

*** RECORDED FLOW, St. Mary River (in cms-days from daily values table) *******

Apr.	__________	Aug.	__________	March		Nov.	__________
May	__________	Sept.	__________	__________ x 86.4		Dec.	__________
June	__________	Oct.	__________			Jan.	__________
July	__________	Total	__________ x 86.4	__________ (DAM3)		Feb.	__________
					Total (cms-days)		__________ x 86.4

Irrigation season ____________ (DAM3)

Non-irrigation season ____________ (DAM3) Total (DAM3) ____________
(Nov. to Mar.) (Nov. to Feb.)

*** NATURAL FLOW, non-irrigation season, in DAM3 (from above) *****************

Lake Sherburne storage (Oct. 30 to Feb. 27/28) __________

St. Mary River recorded flows (Nov. 1 to Feb. 28/29) + __________

Natural flow for March (from Table 6 or INT-2) + __________

Total ____________

*** NATURAL FLOW, irrigation season, in DAM3 (from Table 6) *******************

Apr.	__________	June	__________	Aug.	__________	Oct.	__________
May	__________	July	__________	Sept.	__________	Total	____________

*** NATURAL FLOW, November to October (from above) ****************************

Natural flow, irrigation season (DAM3) ____________

Natural flow, non-irrigation season (DAM3) + ____________

Natural flow, November to October (DAM3) ____________

Computed by:________ Date:________ Checked by:________ Date:________

INT-3

ST. MARY RIVER AT INTERNATIONAL BOUNDARY
WORKSHEET TO COMPUTE ANNUAL SUMMARIES FOR IJC REPORT
FOR THE PERIOD NOVEMBER 1989 TO OCTOBER 1990

*** LAKE SHERBURNE ***

Dates	Gage height (at 2400 hrs)	Contents (cfs-days)		Contents (DAM3)
Feb. 27/28	63.10	16,571		
Oct. 30 (previous year)	50.51	- 9,851		
	Storage	6,720	x 2.4466 =	16 441

*** RECORDED FLOW, St. Mary River (in cms-days from daily values table) *******

Apr.	406.75	Aug.	535.2	March		Nov.	272.13
May	1065.7	Sept.	491.1	88.06 x 86.4		Dec.	127.27
June	1779.1	Oct.	334.15			Jan.	100.94
July	853.0	Total	5465 x 86.4	7608 (DAM3)		Feb.	71.62
				Total (cms-days)			571.96 x 86.4
Irrigation season			472 176	(DAM3)			
Non-irrigation season (Nov. to Mar.)			57 026	(DAM3)	Total (DAM3) (Nov. to Feb.)		49 417

*** NATURAL FLOW, non-irrigation season, in DAM3 (from above) *****************

Lake Sherburne storage (Oct. 30 to Feb. 27/28)		16 441
St. Mary River recorded flows (Nov. 1 to Feb. 28/29)	+	49 417
Natural flow for March (from Table 6 or INT-2)	+	14 872
Total		80 730

*** NATURAL FLOW, irrigation season, in DAM3 (from Table 6) *******************

Apr.	54 242	June	257 205	Aug.	70 791	Oct.	39 884
May	157 516	July	131 873	Sept.	63 810	Total	775 321

*** NATURAL FLOW, November to October (from above) ****************************

Natural flow, irrigation season (DAM3)		775 321
Natural flow, non-irrigation season (DAM3)	+	80 730
Natural flow, November to October (DAM3)		856 051

Computed by: RBB Date: 91-01-11 Checked by: DAB Date: 91-01-11

INT-1C

NATURAL FLOW AND WATER DIVISION OF ST. MARY RIVER AT INTERNATIONAL BOUNDARY
AUGUST 1990
QUANTITIES IN CFS-DAYS

DAY	CHANGE IN CONTENTS OF LAKE SHERBURNE (WITH 1 DAY LAG)	DIVERTED BY ST. MARY CANAL	TOTAL USED BY UNITED STATES	ST.MARY RIVER AT INTERNATIONAL BOUNDARY	NATURAL FLOW AT INTERNATIONAL BOUNDARY	SHARES OF NATURAL FLOW UNITED STATES	SHARES OF NATURAL FLOW CANADA	FLOW IN EXCESS OR DEFICIT (-) OF CANADIAN SHARE
1	-155	617	462	860	1322	494	828	32
2	-103	615	512	816	1328	497	831	-15
3	-171	615	444	775	1219	443	776	-1
4	-120	612	492	734	1226	446	780	-46
5	-153	611	458	687	1145	406	739	-52
6	-238	611	373	674	1047	357	690	-16
7	-269	611	342	654	996	331	665	-11
8	-309	610	301	632	933	300	633	-1
9	-265	609	344	613	957	312	645	-32
10	-296	609	313	596	909	288	621	-25
11	-277	608	331	574	905	286	619	-45
12	-282	605	323	555	878	272	606	-51
13	-296	605	309	528	837	252	585	-57
14	-301	603	302	507	809	238	571	-64
15	-292	603	311	486	797	232	565	-79
S.TOTAL	-3527	9144	5617	9691	15308	5154	10154	-463
MEAN	-235	610	374	646	1021	344	677	-30.9
AC/FT	-6996	18137	11141	19222	30363	10223	20140	-918
16	-337	604	267	521	788	227	561	-40
17	-360	603	243	524	767	217	550	-26
18	-404	603	199	521	720	193	527	-6
19	-370	603	233	512	745	206	539	-27
20	-361	604	243	550	793	230	563	-13
21	-306	603	297	535	832	249	583	-48
22	-373	603	230	524	754	210	544	-20
23	-355	602	247	509	756	211	545	-36
24	-317	603	286	506	792	229	563	-57
25	-441	603	162	505	667	167	500	5
26	-320	602	282	497	779	223	556	-59
27	-356	602	246	483	729	198	531	-48
28	-426	603	177	474	651	163	488	-14
29	-453	602	149	467	616	154	462	5
30	-477	603	126	459	585	146	439	20
31	-473	601	128	443	571	143	428	15
S.TOTAL	-6129	9644	3515	8030	11545	3166	8379	-349
MEAN	-383	603	220	502	722	198	524	-21.8
AC/FT	-12157	19129	6972	15928	22900	6280	16620	-692
TOTAL	-9656	18788	9132	17721	26853	8320	18533	-812
MEAN	-311	606	295	572	866	268	598	-26.2
AC/FT	-19153	37266	18113	35150	53263	16503	36760	-1611

APPROVED BY : ______________________ FOR THE UNITED STATES ______________________ FOR CANADA

INT-2C PROVISIONAL

DAILY SUMMARY OF CONTENTS

05015500 LAKE SHERBURNE AT SHERBURNE, MT 05AE036

AUGUST 1990

Day	Gage height at 2400 hrs (feet)	Contents at 2400 hrs (cfs-days)	24-hr Change in Contents (cfs-days)
1	87.48	33762	-103
2	87.28	33591	-171
3	87.14	33471	-120
4	86.96	33318	-153
5	86.68	33080	-238
6	86.36	32811	-269
7	85.99	32502	-309
8	85.67	32237	-265
9	85.31	31941	-296
10	84.97	31664	-277
11	84.62	31382	-282
12	84.25	31086	-296
13	83.87	30785	-301
14	83.50	30493	-292
15	83.07	30156	-337
16	82.61	29796	-360
17	82.09	29392	-404
18	81.61	29022	-370
19	81.14	28661	-361
20	80.74	28355	-306
21	80.25	27982	-373
22	79.78	27627	-355
23	79.36	27310	-317
24	78.77	26869	-441
25	78.34	26549	-320
26	77.86	26193	-356
27	77.28	25767	-426
28	76.66	25314	-453
29	76.00	24837	-477
30	75.34	24364	-473
31	74.67	23889	-475

Computed by:_______ Date:________ Checked by:________ Date:________

4.6 MAILING LIST FOR INTERIM REPORTS

Interim reports of natural flow and water division, form INT-1 or INT-1C, along with a cover letter, are routinely mailed to the following:

U.S. Bureau Of Reclamation
P.O. Box 700
Malta, MT 59538-0700

U.S. Bureau of Reclamation
Montana Projects Office
P.O. Box 30137
Billings, MT 59107-0137

U.S. Bureau Of Reclamation
P.O. Box 4
Babb, MT 59411

R.A. Halliday
Regional Director
Inland Waters Directorate
Western and Northern Region
Room 300, Park Plaza
2365 Albert Street
Regina, SK S4P 4K1

R.K. Deeprose
Director
Technical Services Division
Alberta Environment
10th Floor, Oxbridge Place
9820 - 106th Street
Edmonton, AB T5K 2J6

J.A. Moreland
District Chief
U.S. Geological Survey
Water Resources Division
Room 428, Federal Building
301 South Park Avenue, Drawer 10076
Helena, MT 59626

5.0 MILK RIVER

5.1 INTRODUCTION

The waters of the Milk River are divided in accordance with the Order of the IJC dated October 4, 1921. In general terms, Rule II states that during the irrigation season (April 1 to October 31) the United States shall be entitled to three-fourths of the natural flow at the eastern crossing of the International Boundary when the natural flow is 666 ft^3/s (18.9 m^3/s) or less. Flows in excess of that quantity are divided equally between the two countries. During the non-irrigation season, the natural flow at the eastern crossing of the International Boundary shall be divided equally between the two countries.

Natural flow computations for the irrigation season are made on a daily basis with interim division reports distributed semi-monthly to interested agencies.

A schematic map (No. 3 in Appendix K) depicts the Milk River basin and shows the monitored points used in the natural flow computations.

During the irrigation season, water is diverted from the St. Mary River in the United States, via the St. Mary Canal, to the North Milk River. In essence then, the Milk River is used as a conveyance channel so that the United States share of the St. Mary River can be utilized for irrigation in the lower United States portion of the Milk River basin.

In very general terms, during the irrigation season, the natural flow of the Milk River at the eastern crossing of the International Boundary is calculated by utilizing the recorded discharge records for North Fork Milk River above St. Mary Canal, North Milk River near International Boundary, Milk River at Western Crossing, Verdigris Coulee near the Mouth, and Milk River at Eastern Crossing. In addition, adjustments are made for increased evaporation losses attributable to diverted St. Mary River waters, and waters utilized for irrigation (consumptive uses) in both countries. During the periods when the St. Mary River diversion is zero, the natural flow is assumed to be that flow being recorded at Milk River at Eastern Crossing of the International Boundary minus the flow of Verdigris Coulee plus the consumptive uses for agriculture. The natural flow during the non-irrigation season is approximated as the recorded flow of Milk River at Milk River, Alberta.

5.2 PROCEDURE FOR DETERMINING NATURAL FLOW

5.2.1 Division Periods

During the irrigation season, tentative natural flow and water division computations are made semi-monthly with calculations being made on a daily basis. During the non-irrigation season, no tentative computations are made.

5.2.2 Hydrologic Factors

There are many factors which should be taken into consideration when computing the natural flow of the Milk River. Among these are tributary inflows, ground water contributions, surface water evaporation, channel losses, and bank storage. Due to water diverted from the St. Mary River to the Milk River via the St. Mary Canal, these factors cannot be studied individually. Consequently, a collective term, net east-west change, is used to describe the combined effect of all factors when computing the natural flow. Net east-west change is simply the arithmetic difference between the recorded flow at Eastern Crossing and the recorded flows at the western crossings.

5.2.3 Evaporation/Evapotranspiration

There is increased evaporation from the surface area of the Milk River due to the additional water from the St. Mary Canal. This incremental evaporation loss is the computed difference of how much water was lost to the atmosphere under actual conditions as compared to what would have been lost under natural conditions.

Prior to diversion from the St. Mary basin, surveys were conducted along the Milk River which were used to develop relationships of discharge versus area, and then discharge versus unit evaporation. This second relationship, in table form, along with pan evaporation data from Whiskey Gap (observer) and Manyberries (experiment station), was used to determine the incremental evaporation loss due to St. Mary Canal water from 1952 to 1987. Prior to 1952, the Spreckly Formula was used in the computations.

In 1988 an evapotranspiration model based on studies by F. I. Morton (1978, 1979, 1985) replaced pan evaporation in the final calculation. A summary of Morton's studies in the Milk River basin can be found in Thompson (1986).

5.2.4 Consumptive Uses

5.2.4.1 Irrigated Agriculture Prior to the mid-seventies, uses of the natural flow of the Milk River by Canada and the United States were assumed to be less than their respective shares and no formal apportionment was made. By 1977, it became apparent that the increasing numbers of sprinkler irrigation systems were capable of using all of the natural flow for long periods of time. Consequently, a more comprehensive natural flow computation and water division procedure was developed and has been used since 1985. The revised computation procedure includes an approximate accounting of irrigation consumptive uses in both countries.

Irrigation consumptive uses are described in detail by Thompson (1986). They are approximations for an "average" year and are given below.

Milk River mean daily water consumption for irrigation
(cubic metres per second)

PERIOD	UNITED STATES	CANADA
Apr 1 - May 15	0.00	0.00
May 16 - 31	1.16	0.71
Jun 1 - 15	1.16	0.74
Jun 16 - 30	0.17	0.28
Jul 1 - 31	0.31	0.51
Aug 1 - 31	0.25	0.42
Sep 1 - 15	0.17	0.28
Sep 16 - Oct 31	0.00	0.00

These consumptive use figures, with some downward adjustment for dry years, have been used since 1985. Periodic reviews should be made of water rights and reports of usage in the basin, and revisions to the average year consumption should be made accordingly.

Beginning in 1991, a method of adjusting these average values by a factor (0.8, 0.9, 1.1, etc.) was proposed to provide for a more systematic adjustment to seasonal precipitation patterns, water availability, field observations, and reports of usages. Since most of the water used is from high elevation runoff or from the St. Mary-water-laden Milk River, the adjustments should be small except in the most extreme cases. A brief discussion of hydrologic conditions and agricultural consumption should be included in the IJC Report.

5.2.4.2 Municipal and Domestic Consumption The Milk River basin above Eastern Crossing is sparsely populated farm and range land. According to Thompson (1986), municipal and domestic consumption is small in comparison to other uses at this time; therefore, no accounting of those uses is made.

5.2.4.3 Verdigris Coulee Verdigris Coulee is discussed here because, in the computations, it is treated as a negative consumptive use. That is, it is used to decrease the Canadian agricultural consumptive use.

Prior to 1986, Verdigris Coulee was a dry channel, the headwater of which is Weston Lake. Weston Lake, and then Verdigris Lake, are now being artificially recharged with water from Ridge Reservoir to the west. The water flowing at Verdigris Coulee near the Mouth is recharge water that has overflowed both lakes, and is credited to Canada.

5.2.5 West-East travel time

To accommodate the approximately 320 river kilometres (200 miles) from the western crossing to the eastern crossing of the International Boundary, flows at the western crossing are lagged by four days in the computations. For example, the flows in the North Fork Milk River, North Milk River, and the Milk River at Western Crossing that occur on May 1 are used to compute the natural flow at Eastern Crossing on May 5. Flows at Verdigris Coulee near the Mouth are lagged by two days.

Prior to 1991, a lag time of five days was used in the computations, as shown by dye studies; however, hydrograph comparisons indicated that the shorter flood wave travel time resulted in more realistic natural flow hydrographs.

5.2.6 Natural Flow Computations

5.2.6.1 Provisional Computations Currently, provisional semi-monthly natural flow computations are made in the United States because of readily available DCP data. Also, because evapotranspiration data from the meteorological gauges in Alberta are not user ready, pan evaporation data from the Ft. Assiniboine Experiment Station near Havre, Montana, is used to compute evaporation losses.

Once the data are entered into data files, all computations are done using the computer. The major difference from the final computations is the use of the "Hanson equation" to compute the incremental evaporation loss due to St.

Mary Canal water. This equation computes this loss using the difference in North Fork and North Milk River flow and four-day average pan evaporation. The results are generally quite similar to the final computations. The "Hanson equation" is explained in Appendix C.

5.2.6.2 Final Computations Final natural flow computations are done in WRB, Calgary using the MILKNAT program (Khanna, 1989). This program uses final discharge data from the pertinent streamflow gauges, consumptive irrigation uses for both countries, and evapotranspiration data as applied to F.I. Morton's model to calculate incremental evaporation loss due to St. Mary Canal water.

Any negative natural flows are assumed to be "zero" in both provisional and final computations.

5.3 WATER DIVISION

5.3.1 Shares

In accordance with the IJC Order of 1921, the United States is entitled to three-fourths and Canada one-fourth of the natural flow of the Milk River at the Eastern Crossing of the International Boundary during the irrigation season (April 1 to October 31) when the natural flow is 666 ft^3/s (18.9 m^3/s) or less. Flows in excess of that are divided equally between the two countries, as are flows during the non-irrigation season (November 1 to March 31).

Both provisional and final computations are done using the computer and both programs have internal equations to accurately determine each country's share of natural flow on a daily basis.

5.3.2 Excess and Deficit Flows

The 1921 Order is not very explicit on the accounting procedure for excess or deficit flows in any given period. As a result, the following procedure has evolved: deficit flows carry over from one period to another, are cumulative, and must be made up by subsequent excess flows; excess flows do not carry over from one period to another, are not cumulative, and cannot be used to make up future deficits.

5.3.3 St. Mary and Milk Rivers Streamflow Transfer

In the dry 1980's, Canada frequently used more than its share of the Milk River flow in the summer months and was allowed to divert a portion of its share of the St. Mary River into the Milk River via the United States' St. Mary Canal. The procedure to allow this was dependent on the status of natural flow computations, phone calls, a series of letters, and anticipation of summer runoff conditions. In 1990, an attempt to formalize an interagency agreement to streamline the procedure only seemed to complicate the issue further.

In 1991, the Accredited Officers agreed that the greatest beneficial use of the waters of the St. Mary and Milk rivers could be achieved by simply allowing Canada to accumulate a deficit on the Milk River until the end of September. In exchange, the United States would be allowed to accumulate a deficit on the St. Mary River from March to May, during which time the United States is usually diverting as much water as possible into the Milk River system. Both deficits would be limited to 4 900 dam^3 (2,000 cfs-days), and would be made up with future surplus deliveries or a balance of deficits between the two river systems. The Letter of Intent is given in Appendix B.

5.4 PUBLICATION DATA FOR IJC REPORT

5.4.1 Computation Units

Two streamflow stations used in the computations of Milk River natural flow are located in the United States, and daily streamflows are computed in Imperial units. When finalized, these records are converted to SI units and entered into the MILKNAT program. The remainder of the streamflow stations are located in Canada and are operated and computed in SI units. However, the DCPs on all Milk River gauges operate in Imperial units, are retrievable in the United States, and are used to compute provisional natural flows in Imperial units.

5.4.2 Tables 2 and 2A

Table 2 is a summary of water division data taken directly from the final monthly division tables, Table 8 in Appendix A of the IJC Report. Table 2A is the Imperial version of Table 2, and is simply the SI values in Table 2 multiplied by 0.8107.

5.4.3 Tables 8 and 9

These tables are fairly self-explanatory. Table 8 is the final monthly SI water division sheets for the Milk River at Eastern Crossing. Table 9 is the historical summary of the natural flow and water division of the Milk River. Both of these tables are part of Appendix A of the IJC Report.

5.5 COMPUTATION FORMS

On the following pages are examples of:

1. Provisional natural flow of Milk River at Eastern Crossing for August, 1990.
2. Final MILKNAT output (4 pages)

PROVISIONAL

NATURAL FLOW OF MILK RIVER AT EASTERN CROSSING
AUGUST 1990
QUANTITIES IN CFS-DAYS

	ACTUAL FLOW					*EVAPORATION		CONSUMPTIVE USE		NATURAL FLOW	SHARES OF NATURAL FLOW		
DAY	N.FK. ABOVE CANAL (1)	NORTH MILK (1)	MILK WEST XING (1)	VERDIGRIS COUL. (2)	MILK EAST XING	AVEG EVAP (IN.) (3)	EVAP LOSS (CFS) (4)	U.S.	CAN.	EAST XING	U.S.	CAN.	FLOW IN EXCESS OR DEFICIT (-) OF U.S. SHARE
1	14	628	97	1	660	0.27	34	9	14	103	77	26	12
2	13	628	66	1	607	0.29	36	9	14	51	38	13	-1
3	12	625	52	2	593	0.30	38	9	13	40	30	10	-3
4	12	624	47	2	587	0.29	36	9	13	33	25	8	-5
5	11	609	37	3	581	0.29	36	9	12	40	30	10	-2
6	12	598	31	3	561	0.30	37	9	12	33	25	8	-4
7	14	598	34	2	531	0.35	43	9	13	12	9	3	-10
8	13	592	26	1	508	0.33	40	9	14	0	0	0	-14
9	12	589	21	1	494	0.37	45	9	14	0	0	0	-14
10	11	587	20	1	483	0.33	40	9	14	0	0	0	-14
11	10	583	19	1	486	0.31	37	9	14	0	0	0	-14
12	10	581	17	1	494	0.31	37	9	14	0	0	0	-14
13	10	584	15	1	497	0.26	31	9	14	0	0	0	-14
14	11	584	14	1	495	0.31	37	9	14	0	0	0	-14
15	11	582	12	1	491	0.28	34	9	14	0	0	0	-14
S.TOTAL	176	8992	508	22	8068	4.59	561	135	203	311	234	78	-125
16	11	581	11	1	497	0.33	40	9	14	0	0	0	-14
17	11	579	10	3	506	0.30	36	9	12	0	0	0	-12
18	10	579	9	4	518	0.25	30	9	11	0	0	0	-11
19	10	579	8	6	660	0.25	30	9	9	139	104	35	26
20	12	585	9	3	647	0.19	23	9	12	118	89	29	17
21	12	581	11	4	627	0.21	25	9	11	103	77	26	15
22	12	584	35	4	637	0.22	27	9	11	112	84	28	17
23	12	584	17	4	593	0.20	24	9	11	65	49	16	5
24	15	593	19	4	571	0.21	25	9	11	38	28	10	-1
25	14	589	18	4	703	0.18	22	9	11	170	128	42	31
26	12	586	29	4	685	0.13	16	9	11	147	110	37	26
27	11	581	33	4	636	0.15	18	9	11	104	78	26	15
28	11	583	26	5	613	0.15	18	9	10	78	58	20	10
29	13	587	22	5	600	0.21	25	9	10	70	52	18	8
30	14	589	21	5	575	0.26	31	9	10	50	37	13	3
31	13	588	21	5	558	0.25	30	9	10	32	24	8	-2
S.TOTAL	193	9348	299	65	9626	3.49	421	144	175	1227	918	308	133
TOTAL	369	18340	807	87	17694	8.08	982	279	378	1538	1152	386	8
AC/FT	732	36377	1601	173	35096		1948	553	750	3051	2285	766	16

Computed by:____________ Date:________ Checked by:____________ Date:________

1--Four day lag incorporated
2--Two day lag incorporated
3--Pan evaporation data from Fort Assinniboine NWS site (*four day average)
4--Evaporation loss using Hanson equation

TABLE 1
SUMMARY OF DAILY
NET CHANGE, NATURAL FLOW, EVAPORATIVE AND NET CONSUMPTIVE USES OF MILK RIVER AT EASTERN CROSSING OF INTERNATIONAL BOUNDARY
AUGUST , 1990

1 Date at East X-ing	2 Natural Flow at West X-ing (C9,T2)	3 Net East-West Change (C10,T2)	4 Incmntl. Evapo-trans. Loss (C8,T4)	Total Consumptive Use		7 Natural Flow at East X-ing (2+3+4+5+6)	Share		10 Excess(+)/Deficit(-) Delivery U.S. (9-6)	11 Cumulative Excess(+)/Deficit(-) Delivery U.S.
				5 U.S. (C3,T3)	6 Canada (C8,T3)		8 U.S.	9 Canada		
AUG 1	325.4	-204.8	76.9	21.6	35.1	254.2	190.7	63.6	+ 28.5	+ 28.5
AUG 2	271.0	-288.6	46.3	21.6	34.1	84.3	63.2	21.1	- 13.0	+ 15.5
AUG 3	193.4	-248.0	66.9	21.6	31.3	65.1	48.9	16.3	- 15.0	+ 0.5
AUG 4	157.2	-222.9	95.4	21.6	31.9	83.2	62.4	20.8	- 11.1	- 10.6
AUG 5	143.4	-217.7	91.6	21.6	29.6	68.6	51.4	17.1	- 12.5	- 23.1
AUG 6	117.6	-203.0	104.8	21.6	29.7	70.7	53.0	17.7	- 12.1	- 35.2
AUG 7	106.0	-240.8	101.0	21.6	32.0	19.8	14.9	5.0	- 27.0	- 62.2
AUG 8	117.8	-299.5	87.8	21.6	34.7	0.0	0.0	0.0	- 34.7	- 96.9
AUG 9	95.6	-305.8	54.5	21.6	34.6	0.0	0.0	0.0	- 34.6	- 131.5
AUG 10	80.9	-310.7	82.8	21.6	34.4	0.0	0.0	0.0	- 34.4	- 165.9
AUG 11	75.5	-290.6	95.0	21.6	34.3	0.0	0.0	0.0	- 34.3	- 200.2
AUG 12	70.2	-261.7	81.7	21.6	34.1	0.0	0.0	0.0	- 34.1	- 234.4
AUG 13	65.1	-248.0	67.4	21.6	34.1	0.0	0.0	0.0	- 34.1	- 268.4
AUG 14	62.0	-253.6	74.1	21.6	33.9	0.0	0.0	0.0	- 33.9	- 302.3
AUG 15	60.1	-257.9	65.7	21.6	33.7	0.0	0.0	0.0	- 33.7	- 336.0
15-Day Tot	1941.1	-3853.5	1192.0	324.0	497.5	646.0	484.5	161.5	- 336.0	- 336.0
AUG 16	55.0	-235.4	87.8	21.6	33.5	0.0	0.0	0.0	- 33.5	- 33.5
AUG 17	53.6	-208.1	43.5	21.6	29.3	0.0	0.0	0.0	- 29.3	- 62.8
AUG 18	50.3	-170.3	64.0	21.6	25.5	0.0	0.0	0.0	- 25.5	- 88.3
AUG 19	46.1	177.1	34.1	21.6	22.8	301.7	226.2	75.4	+ 52.6	- 35.7
AUG 20	44.5	144.1	58.8	21.6	28.3	297.2	222.9	74.3	+ 46.0	+ 10.3
AUG 21	51.0	82.1	81.0	21.6	27.7	263.4	197.5	65.8	+ 38.1	+ 48.4
AUG 22	55.3	103.7	45.1	21.6	27.1	252.8	189.6	63.2	+ 36.1	+ 84.5
AUG 23	115.8	-60.5	59.9	21.6	26.9	163.7	122.7	40.9	+ 14.0	+ 98.5
AUG 24	69.9	-66.4	16.1	21.6	26.7	67.9	50.9	17.0	- 9.7	+ 88.8
AUG 25	83.0	221.5	16.2	21.6	26.4	368.7	276.6	92.2	+ 65.8	+ 154.6
AUG 26	78.1	189.4	25.3	21.6	25.9	340.4	255.3	85.1	+ 59.2	+ 213.7
AUG 27	100.1	50.2	88.6	21.6	25.2	285.8	214.3	71.4	+ 46.2	+ 259.9
AUG 28	107.0	6.3	88.9	21.6	24.9	248.7	186.5	62.2	+ 37.3	+ 297.2
AUG 29	89.2	-19.1	46.7	21.6	24.9	163.2	122.4	40.8	+ 15.9	+ 313.1
AUG 30	85.6	-79.7	30.9	21.6	24.7	83.1	62.3	20.8	- 3.9	+ 309.2
AUG 31	84.3	-127.9	82.5	21.6	23.8	84.4	63.3	21.1	- 2.7	+ 306.5
16-Day Tot	1168.6	6.9	869.4	345.6	423.7	2920.9	2190.7	730.2	+ 306.5	+ 306.5
AUG Totals	3109.8	-3846.6	2061.4	669.6	921.2	3566.9	2675.2	891.7	- 29.5	- 29.5

(i) ALL FIGURES ARE IN CUBIC DECAMETRES.

(ii) FIVE DAY LAG PERIOD IS APPLIED BETWEEN WEST AND EAST TO DETERMINE THE NATURAL FLOW AT EASTERN CROSSING.

APPROVED BY:________________________FOR CANADA ________________________FOR THE UNITED STATES

TABLE 2
SUMMARY OF DAILY
ACTUAL FLOWS IN THE MILK RIVER BASIN
AUGUST , 1990

1 Date at East X-ing	2 North Fk. Milk River Above St. Mary Canal 11AA032	3 North Milk River Nr. Internatl Boundary 11AA001	Milk River at		6 Diversion from St.Mary Basin (3-2)	7 Total Flow at West X-ing (3+4)	8 East-West Mean Flow (5+7)/2.	9 Natural Fl at West X-ing (2+4)	10 Net East-West Change (5-7)	11 Milk River at Milk River 11AA005
			4 West X-ing 11AA025	5 East X-ing 11AA031						
AUG 1	34.2	1529.3	291.2	1615.7	1495.1	1820.4	1718.1	325.4	-204.8	1589.8
AUG 2	34.2	1537.9	236.7	1486.1	1503.7	1774.7	1630.4	271.0	-288.6	1546.6
AUG 3	31.8	1537.9	161.6	1451.5	1506.1	1699.5	1575.5	193.4	-248.0	1520.6
AUG 4	29.4	1529.3	127.9	1434.2	1499.9	1657.2	1545.7	157.2	-222.9	1486.1
AUG 5	29.4	1529.3	114.0	1425.6	1499.9	1643.3	1534.5	143.4	-217.7	1451.5
AUG 6	26.9	1486.1	90.7	1373.8	1459.2	1576.8	1475.3	117.6	-203.0	1425.6
AUG 7	29.4	1460.2	76.6	1296.0	1430.8	1536.8	1416.4	106.0	-240.8	1417.0
AUG 8	34.2	1460.2	83.5	1244.2	1425.9	1543.7	1393.9	117.8	-299.5	1408.3
AUG 9	31.8	1451.5	63.8	1209.6	1419.7	1515.4	1362.5	95.6	-305.8	1417.0
AUG 10	29.4	1442.9	51.5	1183.7	1413.5	1494.4	1339.0	80.9	-310.7	1408.3
AUG 11	26.9	1434.2	48.6	1192.3	1407.4	1482.9	1337.6	75.5	-290.6	1399.7
AUG 12	24.5	1425.6	45.7	1209.6	1401.1	1471.3	1340.5	70.2	-261.7	1391.0
AUG 13	24.5	1425.6	40.6	1218.2	1401.1	1466.2	1342.2	65.1	-248.0	1391.0
AUG 14	24.5	1425.6	37.6	1209.6	1401.1	1463.2	1336.4	62.0	-253.6	1382.4
AUG 15	26.9	1425.6	33.3	1201.0	1398.7	1458.9	1329.9	60.1	-257.9	1365.1
15-Day Tot	437.7	22101.1	1503.4	19751.0	21663.4	23604.6	21677.8	1941.1	-3853.5	21600.0
AUG 16	26.9	1425.6	28.1	1218.2	1398.7	1453.7	1336.0	55.0	-235.4	1365.1
AUG 17	26.9	1417.0	26.7	1235.5	1390.1	1443.7	1339.6	53.6	-208.1	1408.3
AUG 18	26.9	1417.0	23.4	1270.1	1390.1	1440.4	1355.2	50.3	-170.3	1442.9
AUG 19	24.5	1417.0	21.6	1615.7	1392.5	1438.6	1527.1	46.1	177.1	1477.4
AUG 20	24.5	1417.0	20.0	1581.1	1392.5	1437.0	1509.1	44.5	144.1	1451.5
AUG 21	29.4	1434.2	21.6	1537.9	1404.9	1455.8	1496.9	51.0	82.1	1451.5
AUG 22	29.4	1425.6	25.9	1555.2	1396.2	1451.5	1503.4	55.3	103.7	1434.2
AUG 23	29.4	1425.6	86.4	1451.5	1396.2	1512.0	1481.8	115.8	-60.5	1442.9
AUG 24	29.4	1425.6	40.5	1399.7	1396.2	1466.1	1432.9	69.9	-66.4	1468.8
AUG 25	36.7	1451.5	46.3	1719.4	1414.8	1497.8	1608.6	83.0	221.5	1486.1
AUG 26	34.2	1442.9	43.9	1676.2	1408.7	1486.8	1581.5	78.1	189.4	1503.4
AUG 27	29.4	1434.2	70.8	1555.2	1404.9	1505.0	1530.1	100.1	50.2	1486.1
AUG 28	26.9	1417.0	80.1	1503.4	1390.1	1497.1	1500.2	107.0	6.3	1468.8
AUG 29	26.9	1425.6	62.3	1468.8	1398.7	1487.9	1478.3	89.2	-19.1	1460.2
AUG 30	31.8	1434.2	53.8	1408.3	1402.4	1488.1	1448.2	85.6	-79.7	1451.5
AUG 31	34.2	1442.9	50.1	1365.1	1408.7	1493.0	1429.1	84.3	-127.9	1451.5
16-Day Tot	467.1	22852.8	701.6	23561.3	22385.7	23554.4	23557.8	1168.6	6.9	23250.2
AUG Totals	904.8	44953.9	2205.0	43312.3	44049.1	47158.9	45235.6	3109.8	-3846.6	44850.2

(i) ALL FIGURES ARE IN CUBIC DECAMETRES.

(ii) FIVE DAY LAG FLOW FIGURES ARE USED TO DETERMINE THE NATURAL FLOW AT EASTERN CROSSING.

TABLE 3
SUMMARY OF DAILY
CONSUMPTIVE USE IN MILK RIVER BASIN
AUGUST , 1990

1	Consumptive Use in U.S.		Consumptive Use in Canada				
Date at East X-ing	2 Irrigation	3 Total	4 Irrigation	5 Storage(+) Release(-)	6 Reservoir Evap.	7 Interbasin Transfer(-) Verdigris Cl. 11AA038	8 Total (4+5+6+7)
AUG 1	21.6	21.6	36.3	0.0	-	- 1.2	35.1
AUG 2	21.6	21.6	36.3	0.0	-	- 2.2	34.1
AUG 3	21.6	21.6	36.3	0.0	-	- 5.0	31.3
AUG 4	21.6	21.6	36.3	0.0	-	- 4.4	31.9
AUG 5	21.6	21.6	36.3	0.0	-	- 6.7	29.6
AUG 6	21.6	21.6	36.3	0.0	-	- 6.6	29.7
AUG 7	21.6	21.6	36.3	0.0	-	- 4.3	32.0
AUG 8	21.6	21.6	36.3	0.0	-	- 1.6	34.7
AUG 9	21.6	21.6	36.3	0.0	-	- 1.7	34.6
AUG 10	21.6	21.6	36.3	0.0	-	- 1.9	34.4
AUG 11	21.6	21.6	36.3	0.0	-	- 2.0	34.3
AUG 12	21.6	21.6	36.3	0.0	-	- 2.2	34.1
AUG 13	21.6	21.6	36.3	0.0	-	- 2.2	34.1
AUG 14	21.6	21.6	36.3	0.0	-	- 2.2	34.1
AUG 15	21.6	21.6	36.3	0.0	-	- 2.4	33.9
15-Day Tot	324.0	324.0	544.5	0.0	-	- 47.0	497.5
AUG 16	21.6	21.6	36.3	0.0	-	- 2.8	33.5
AUG 17	21.6	21.6	36.3	0.0	-	- 7.0	29.3
AUG 18	21.6	21.6	36.3	0.0	-	- 10.8	25.5
AUG 19	21.6	21.6	36.3	0.0	-	- 13.5	22.8
AUG 20	21.6	21.6	36.3	0.0	-	- 8.0	28.3
AUG 21	21.6	21.6	36.3	0.0	-	- 8.6	27.7
AUG 22	21.6	21.6	36.3	0.0	-	- 9.2	27.1
AUG 23	21.6	21.6	36.3	0.0	-	- 9.4	26.9
AUG 24	21.6	21.6	36.3	0.0	-	- 9.6	26.7
AUG 25	21.6	21.6	36.3	0.0	-	- 9.9	26.4
AUG 26	21.6	21.6	36.3	0.0	-	- 10.4	25.9
AUG 27	21.6	21.6	36.3	0.0	-	- 11.1	25.2
AUG 28	21.6	21.6	36.3	0.0	-	- 11.4	24.9
AUG 29	21.6	21.6	36.3	0.0	-	- 11.4	24.9
AUG 30	21.6	21.6	36.3	0.0	-	- 11.6	24.7
AUG 31	21.6	21.6	36.3	0.0	-	- 12.5	23.8
16-Day Tot	345.6	345.6	580.8	0.0	-	- 157.1	423.7
AUG Totals	669.6	669.6	1125.3	0.0	-	- 204.1	921.2

(i) ALL FIGURES ARE IN CUBIC DECAMETRES.

(ii) VERDIGRIS COULEE IS LAGGED BY TWO DAYS.

TABLE 4
SUMMARY OF DAILY
EVAPOTRANSPIRATION LOSS IN THE MILK RIVER BASIN
AUGUST , 1990

1 Date at East X-ing	2 Evaporation Loss From River Surface (mm)	Transpiration Loss From Phreatophyte		Evaporation Loss based on			8 Incremental Evapotranspiration Loss (4+7)
		3 (mm)	4	5 East-West Mean Flow (C8.T2)	6 Natural Fl. at West X-ing (C9.T2)	7 Increase in Flow (5-6)	
AUG 1	5.55	1.11	20.06	131.2	74.3	56.9	76.9
AUG 2	4.34	0.00	0.00	100.1	53.9	46.3	46.3
AUG 3	5.71	0.00	0.00	129.5	62.7	66.9	66.9
AUG 4	6.10	1.17	21.17	137.1	62.9	74.2	95.4
AUG 5	6.24	0.79	14.38	139.7	62.4	77.2	91.6
AUG 6	6.63	1.11	20.18	145.9	61.2	84.7	104.8
AUG 7	6.59	0.95	17.26	142.3	58.5	83.8	101.0
AUG 8	5.69	1.01	18.26	122.1	52.6	69.5	87.8
AUG 9	4.50	-0.15	-2.74	95.8	38.5	57.3	54.5
AUG 10	5.49	0.61	11.12	116.3	44.6	71.7	82.8
AUG 11	5.73	1.06	19.18	121.4	45.6	75.8	95.0
AUG 12	5.47	0.46	8.42	115.9	42.6	73.3	81.7
AUG 13	4.46	0.38	6.93	94.5	34.0	60.4	67.4
AUG 14	7.21	-1.33	-24.18	152.7	54.4	98.3	74.1
AUG 15	4.65	0.12	2.22	98.3	34.8	63.5	65.7
15-Day Tot	84.36	7.30	132.25	1842.8	783.1	1059.7	1192.0
AUG 16	5.40	0.72	13.02	114.4	39.6	74.8	87.8
AUG 17	3.17	-0.03	-0.59	67.2	23.1	44.1	43.5
AUG 18	3.62	0.72	13.11	76.9	26.0	50.9	64.0
AUG 19	2.11	0.10	1.87	47.1	14.9	32.2	34.1
AUG 20	3.15	0.59	10.76	70.1	22.1	48.0	58.8
AUG 21	4.45	0.80	14.58	98.4	32.1	66.4	81.0
AUG 22	3.67	-0.51	-9.32	81.3	26.9	54.4	45.1
AUG 23	4.05	0.43	7.75	89.3	37.2	52.1	59.9
AUG 24	0.94	0.17	3.07	20.3	7.3	13.0	16.1
AUG 25	0.90	0.17	3.03	20.5	7.3	13.2	16.2
AUG 26	1.39	0.27	4.94	31.5	11.1	20.4	25.3
AUG 27	5.18	0.98	17.74	116.0	45.1	70.9	88.6
AUG 28	5.30	1.03	18.69	117.4	47.2	70.2	88.9
AUG 29	4.44	-0.77	-13.94	97.8	37.2	60.6	46.7
AUG 30	4.44	-1.61	-29.20	96.8	36.7	60.1	30.9
AUG 31	4.90	0.92	16.65	106.1	40.3	65.9	82.5
16-Day Tot	57.09	3.98	72.16	1251.3	454.1	797.3	869.4
AUG Totals	141.45	11.28	204.41	3094.1	1237.1	1857.0	2061.4

(i) ALL FIGURES ARE IN CUBIC DECAMETRES UNLESS OTHERWISE SPECIFIED.

(ii) WHILE USING F. I. MORTON'S MODEL, DAILY VALUES OF EVPOTRANSPIRATION MAY NOT BE REALISTIC DUE TO SUBSURFACE HEAT STORAGE CHANGES AND ITS LAG TIMES ASSOCIATED WITH THE VAPOURS IN THE ATMOSPHERIC BOUNDARY.

5.6 MAILING LIST FOR INTERIM REPORTS

Interim reports of natural flow and water division are routinely mailed to the following:

Bureau of Reclamation
Montana Project Office
P.O. Box 30137
Billings, MT 59107-0137

U.S. Bureau of Indian Affairs
P.O. Box 98
Harlem, MT 59526

No interim reports are distributed to any agencies in Canada.

5.7 REFERENCES

Khanna, V., "Natural Flow User Manual and Program Documentation", July, 1987.

Morton, F.I., "Estimating evapotranspiration from potential evaporation - Practicality of an iconoclastic approach," *Journal of Hydrology*, Vol. 38, p. 1-32.

Morton, F.I., "Climatological estimates of lake evaporation," *Water Resources Research*, Vol. 15., No. 1, p. 64-76.

Morton, F.I., "Operational estimates of areal evapotranspiration and their significance to the science and practice of hydrology," *Journal of Hydrology*, Vol. 66, No. 1-4, p. 1-76.

Morton, F.I., *Milk River evaporation studies during 1982, 1983 and 1984*, Ottawa, Ontario, Environment Canada, February 1985.

Thompson, R. *Natural Flow and Water Consumption in the Milk River Basin, Montana and Alberta, Canada: United States Geological Survey Water Resources Investigations*. Report No. 86-4006, Helena, Montana, U.S.A., 1986.

6.0 EASTERN TRIBUTARIES OF THE MILK RIVER

6.1 INTRODUCTION

Article VI of the Boundary Waters Treaty of 1909 determines the amount of water each country is entitled to receive from the St. Mary and Milk rivers. The measurement and division of the water was made the responsibility of the Reclamation Officers of the United States and the Irrigation Officers of Canada under the direction of the IJC.

The wording of the Treaty was rather ambiguous, and a controversy arose which made it necessary for the IJC to hold a series of hearings at St. Paul, Minnesota; Detroit, Michigan; Ottawa, Ontario; Chinook, Montana; and Lethbridge, Alberta. As a result of these hearings, the IJC issued the October 4, 1921 Order to the Reclamation and Irrigation Officers on how to measure and apportion the water between the United States and Canada.

The sections of the IJC 1921 Order which pertain to the eastern tributaries are as follows:

> Section III The natural flow of the eastern (otherwise known as the Saskatchewan or northern) tributaries of the Milk River at the points where they cross the International Boundary shall be divided equally between the two countries.
>
> Section V For the purpose of carrying out the apportionment directed in Paragraphs I, II, and III hereof the said Reclamation and Irrigation officers shall jointly take steps:
>
> (a) To ascertain and keep a daily record of the natural flow … of the eastern tributaries of the Milk River at the International Boundary by measurement in each case:
>
> (1) At the gauging station at the International Boundary.
> (2) At all places where any of the waters which would naturally flow across the International Boundary at that particular point are diverted in either country prior to such crossing.
> (3) At all places where any of the waters which would naturally flow across the International Boundary at that particular point are stored, or the natural flow thereof increased or decreased prior to such crossing.

To carry out the instructions contained in the Order, a network of gauging stations was established and procedures developed by the Canada and the United States. The computational procedure is essentially a project depletion method whereby diversions, accretions and reservoir storage changes are measured and adjustments made to the recorded flow of the stream at the International Boundary. Adjustment items considered are major diversions, return flow, minor project diversions, reservoir storage change, evaporation, and channel losses. Time of travel is considered by application of an average value.

Although the Order states "... keep a daily record of the natural flow ..." division of flow on this frequency is not practical because of staff, resource, and instrumentation levels which would be required. Presently the division of natural flow is carried out on a 10-day basis, which is considered the smallest practical time interval from an operational and procedural point of view.

During the period March 1 to October 31, reports giving the natural flows of Lodge Creek, Battle Creek, and the Frenchman River and the amount received by the United States are mailed to interested agencies at least every month and every ten days during critical periods. No division of flow is made during the winter period as there is usually very little flow and of that flow, the United States usually receives more than its share.

In 1978, monitoring of Woodpile Coulee, East Fork Battle Creek, and McEachern Creek was suspended. The report "Water Use Development on the Eastern Tributaries of the Milk River" (Johnson, 1978) recommended that the licences in each of the basins should be reviewed annually and the gauging stations be considered for re-activation when the median annual diversion in Canada exceeds 25 percent of the median annual flow recorded at the International Boundary.

At present, Lyons Creek, Whitewater Creek, and Rock Creek, do not have sufficient usage in Canada to warrant a formal apportionment of flow. Lyons Creek continues to be monitored. Whitewater Creek near International Boundary was suspended in 1980 after 53 years of record. In 1981 Rock Creek below Horse Creek was suspended as an international gauging station but it is still operated by the USGS as a regional hydrology station.

6.2 PROCEDURE FOR DETERMINING NATURAL FLOW

6.2.1 Division Periods

From March 1 to October 31 tentative computations of the natural flow are done three times a month, that is, the periods cover the days 1-10, 11-20, 21-30 or 31. The last period of the month may have ten or eleven days, but for convenience, the division periods are generally referred to as "ten-day periods". The computations are done using the forms in Appendix E.

This simple idea of division periods is complicated by the fact that a diversion or a release does not produce an instantaneous change in the flow at the boundary. For instance, water released from Cypress Lake requires an average of nine days to travel the 290 km along the Frenchman River to the International Boundary, a release from Eastend Reservoir requires seven days, and a release from Newton Lake requires three days to reach the boundary. To account for this travel time, the entire river length is divided into several segments and the dates of the division periods lagged proportionally.

Cypress Lake is used as a storage reservoir and for inter-basin transfer of water between Battle Creek and the Frenchman River. In order to account for any inter-basin transfer between the two basins in the same time period and because of the different travel times to the boundary on Battle Creek and the Frenchman River, it was necessary to adjust the division dates for Battle Creek at the International Boundary so that the periods cover the days 5-14, 15-24 or 25, 25 or 26-4. In order to have the same number of division periods in each of the three basins it was necessary to adjust the first and last division periods for Battle Creek to cover the time period March 1-14 (14 days) and October 26-31 (6 days) respectively. It is important to have the same dates at Cypress Lake in the natural flow computations on Battle Creek and the Frenchman River otherwise modelling of the water budget of Cypress Lake by Canadian water management agencies would be difficult.

6.2.2.1 Flows Outside the Normal Period Flows outside the normal runoff period, March 1 to October 31, are usually minor, reservoir storage is minimal, and no irrigation diversions are made. Consequently stations are not operated during this period. The costs of monitoring and apportioning the minor flows in this period are high while the benefits are minimal. If flows or reservoir storage are significant, apportionment is done on an ad hoc basis by the Field Representatives.

6.2.2 Reservoirs

6.2.2.1 Storage Changes Any water stored in a Canadian reservoir is a charge against Canada, and any water released is a credit for Canada. Storage is given a plus (+) sign in the natural flow calculations and release is given a minus (-) sign. The amount of water stored or released during a division period is computed as the difference in reservoir contents between 00:00 hours of the first day of the division period and 24:00 hours of the last day of the period.

6.2.2.2 Net Reservoir Evaporation The construction of a dam creates a reservoir, and the larger surface area of the reservoir (compared to the surface area of the natural stream) does two things:

1. Evaporation is increased.
2. Captured precipitation is increased.

The combined effect of these two factors is referred to as "net reservoir evaporation". The net reservoir evaporation is determined from net pan evaporation data collected at meteorological stations established in co-operation with the Atmospheric Environment Service.

The water in the evaporation pan is maintained at a constant level by either adding or removing water as required on a daily basis. If water must be added to the pan, then evaporation exceeded precipitation. If water must be removed from the pan then precipitation exceeded evaporation. The measurement of the depth of water added or removed from the pan is equivalent to a measure of the net pan evaporation.

Net reservoir evaporation is calculated from the following equation:

$$\text{Net reservoir evaporation in ten-day period } (\text{dam}^3) = \frac{\text{reservoir surface area at mean elev. for period } (\text{dam}^2) \times \text{net pan evaporation in ten-day period(mm)} \times 0.70}{10000 \text{ mm/dam}}$$

The mean elevation of the reservoir for the period is simply the algebraic mean of the elevations at the beginning and end of the period for manual stations. For stations with continuous record, the mean elevation is calculated from the ten or eleven daily means in the period.

The correction factor of 0.70 accounts for:

1. Water evaporating at a greater rate from a pan than from a reservoir.
2. Some of the precipitation falling on the surface area of the reservoir would also have fallen on the surface area and local drainage area of the natural stream.

Following is a list of the major reservoirs in the Frenchman, Battle and Lodge basins and the evaporation stations used to compute reservoir evaporation:

Frenchman River Basin

11AC055 Eastend Reservoir
11AC063 Newton Lake
11AC056 Huff Lake

Evaporation Station is Val Marie

Battle Creek Basin

11AB090 Reesor Reservoir
11AB095 Adams Lake

Evaporation Station is Altawan

Lodge Creek Basin

11AB091 Michel Reservoir
11AB092 Greasewood Reservoir
11AB104 Massy Reservoir
11AB094 Bare Creek Reservoir
11AB097 Cressday Reservoir
11AB099 Mitchell Reservoir
11AB098 Jaydot Reservoir
11AB089 Altawan Reservoir

Evaporation Station is Altawan

6.2.2.3 Example of Net Reservoir Depletion Calculations Following is an example of the calculations for computing net reservoir depletion.

Period	Elevation at end of period (metres)	Contents (dam^3)	Change in Contents During Period (dam^3)	Net Pan Evaporation (mm)	Mean Elevation for Period (metres)	Net Reservoir Evaporation (dam^3)	Net Depletion Storage (+) Release (-) (dam^3)
Apr 24-May 3	918.302	2 463					
May 4-13	918.454	2 717	+254	80.8	918.378	96	+350
. .							
May 25-Jun 3	918.454	2 717					
Jun 4-13	918.302	2 463	-254	80.8	918.378	96	-158
. .							
Jun 24-Jul 3	918.302	2 463					
Jul 4-13	918.454	2 717	+254	-23.0	918.378	-27	+227
. .							
Jul 25-Aug 3	918.454	2 717					
Aug 4-13	918.302	2 463	-254	-23.0	918.378	-27	-281

Explanatory notes:

1. *Elevation at end of period is the elevation at midnight of the last day of the period.*
2. *Net pan evaporation is equivalent to the depth of water added to or removed from the pan required to keep the pan's water level constant. If the number is positive then evaporation was greater than precipitation in the period. If the number is negative then precipitation was greater than evaporation in the period.*
3. *Net depletion is equal to the change in contents plus the net reservoir evaporation.*

Calculations for reservoir evaporation for periods May 4-13 and Jul 4-13.
From stage-area table:
at mean elev. of 918.378 the area is 17 034 dam^2

May 4-13
net reservoir evap. $= \frac{0.70 \times 80.8 \text{ mm} \times 17\,034 \text{ dam}^2}{10\,000 \text{ mm/dam}} = 96 \text{ dam}^3$

July 4-13
net reservoir evap. $= \frac{0.70 \times -23.0 \text{ mm} \times 17\,034 \text{ dam}^2}{10\,000 \text{ mm/dam}} = -27 \text{ dam}^3$

6.2.2.4 Reservoir Contents The daily water levels published by WRB for those reservoirs with recorders are the adjusted water levels. Wind and seiche effects are graphically eliminated from the chart trace. The "smoothed" trace is digitized and the published data reflect the "smoothed" trace. This differs from the normal WRB procedure for reservoirs and lakes of publishing daily water levels "as recorded". For the reservoirs used in the natural flow computations, the adjusted water levels are published because the adjusted water levels are used in determining the reservoir contents for apportionment purposes.

The published instantaneous peak water level is extracted manually from the "as recorded" chart trace (ie. it is not adjusted for wind and seiche effects, unless the peak occurs in a period of minimal wind, in which case the digitized trace would produce a correct peak water level). This procedure is always recorded on the particular station analysis for the year and unless there is a remark of greater importance, it is also recorded on the final listing.

6.2.2.5 Month-end Contents Chart At the end of each month during the irrigation season, a chart is produced which illustrates the month-end contents of Middle Creek Reservoir, Altawan Reservoir, Cypress Lake, Eastend Reservoir, Huff Lake and Newton Lake. Following are the instructions for creating the month-end contents chart.

NOTE: the following instructions are applicable only to the WRB, Regina PC computer system.

The month-end contents chart is a "composite chart" produced with the Harvard Graphics version 2.3 software package. An example of the chart is shown on page 6.9. The chart is composed of the six individual reservoir charts. The month-end contents chart is updated by first updating each of the individual reservoir charts. The historical means for month-end contents are computed from a Lotus 123 spreadsheet stored in C:\internat\charts\monthend.wk3.

1. Insert Environment Canada letterfoot stock into the bypass tray of the HP LaserJet III network printer.

2. At the C:\> prompt type in **cd \internat\charts <Enter>**.

3. At the C:\INTERNAT\CHARTS> prompt type in **hg <Enter>**. This starts up Harvard Graphics.

4. Select **Get/Save/Remove** from the Main Menu. At the Get/Save/Remove menu, select **Get Chart.** Harvard Graphics displays the **Select Chart** screen. Use the **UP** and **DOWN** arrow keys to highlight the chart you wish to edit and press **<Enter>**.

5. The reservoir files are stored as:
   MID_RES.CHT
   ALT_RES.CHT
   CYP_LAKE.CHT
   EAST_RES.CHT
   HUFF_RES.CHT
   NEWT_RES.CHT

6. Update the month-end reservoir data.

   After updates have been made the chart MUST be saved:
   Press **<ESC>** until you are back to the Main Menu and select **Get/Save/Remove** then select **Save Chart.**

7. Repeat steps 4 to 6 for each reservoir.

8. Return to **Get/Save/Remove** and Select the **CONTENTS.CHT** which is the month-end contents chart.

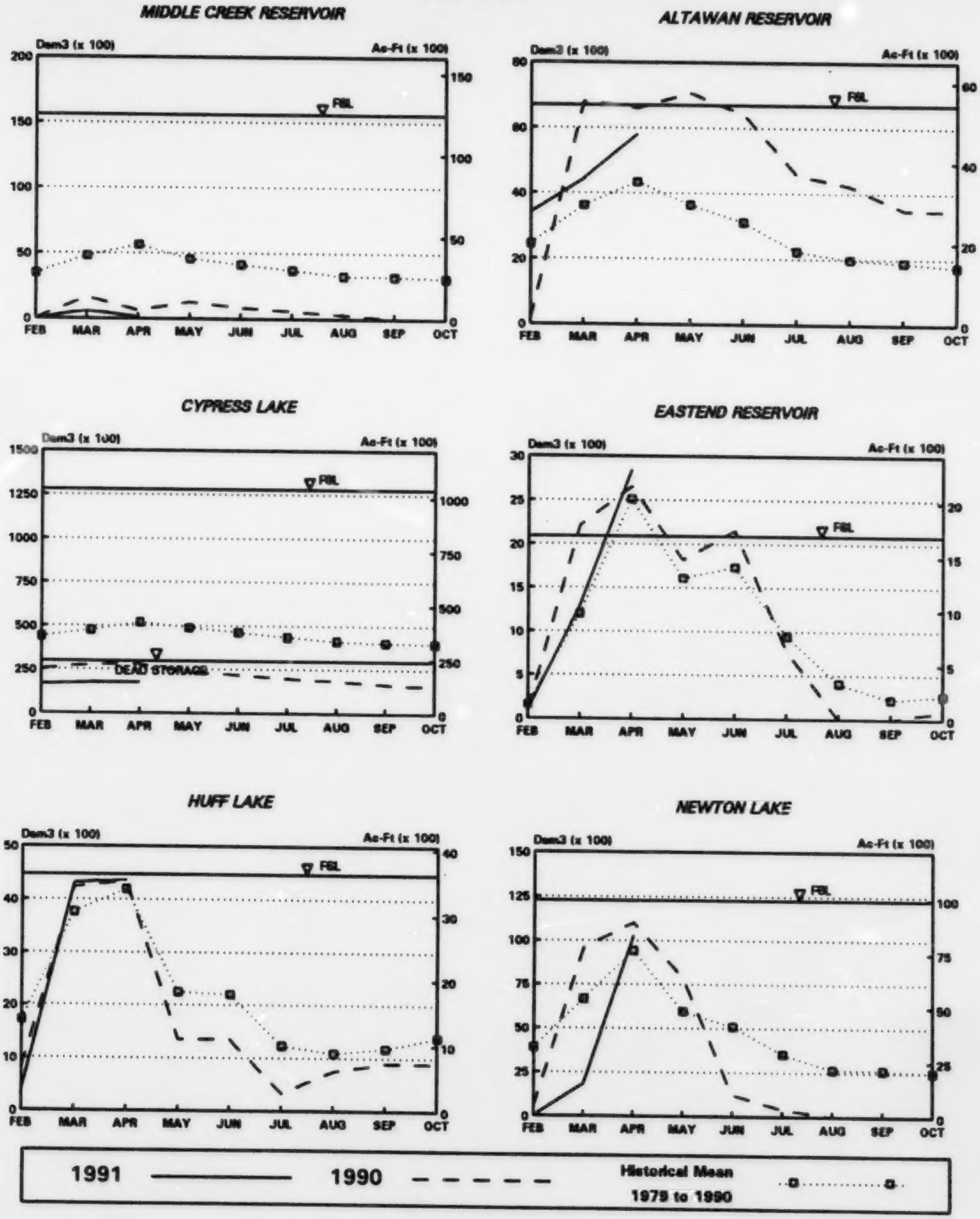
9. Return to the **Main Menu** and select **Draw/Annotate**. Use the **Modify** - **Options** sub-menus to edit the date on the chart.

10. Print the chart in high-quality mode.

RESERVOIRS IN LODGE, BATTLE AND FRENCHMAN BASINS

MONTH-END CONTENTS

May 6, 1991



FSL: Full Supply Level

6.2.3 Minor Diversions

It is impractical to establish gauging stations on the many smaller "minor" diversions, such as small irrigation projects, stockwatering ponds, and domestic usage. Accordingly, the following methods have been used to estimate the minor diversion usage.

Until 1991, for the Frenchman River and Battle Creek, graphs of the ratio of annual minor diversions to the apparent natural flow at the International Boundary versus the annual apparent natural flow were used to estimate minor diversions. An investigation by Yee (1985) showed that these graphs were based on a spurious correlation. For Lodge Creek, minor diversions were estimated from previous years' records.

A new method of estimating minor diversions was developed by Yee (1991).

NOTE: *at time of writing of the Procedures Manual, Mr. Yee's report was still in draft form. When the report is finalized, revised pages will be distributed to all recipients of the the manual.*

A number of the larger minor diversions are monitored to determine usage and to check water use returns. For instance, the usage in the Stokke-Buchanan project is computed from the difference in flow corrected for channel loss between Middle Creek near Govenlock (11AB108) and Middle Creek above Lodge Creek (11AB008). (See section 6.7.2 for details).

At the end of June, reports are received from Alberta Environment and Sask Water on actual reported water usage from the minor projects in each basin in their respective jurisdictions. The interim division reports are updated based on these reports. Minor diversions for the interim division reports for the remainder of the year are estimated from the actual reported use for the first part of the year. At year-end, reports are again received from Alberta Environment and Sask Water on minor project usage. The year-end reports update the information reported in June, and also include any water use from July to October.

At times, there have been more frequent reports on minor diversion use particularly when there is a deficit. The provincial agencies have often made an extra effort to provide more current data on minor diversion use.

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6.2.4 Domestic Projects

A domestic project is defined as a small reservoir which is used for household and/or stockwatering purposes. Estimates of minor diversions have always been included in the natural flow computations; however, it was not until the extremely dry years of 1961 and 1962 that a move was made to include the numerous domestic project usages in the natural flow computations.

From 1966 to 1970 index domestic projects (stockwatering reservoirs) were monitored in the Frenchman River and Battle Creek basins in an effort to arrive at a method for estimating the total domestic project usage.

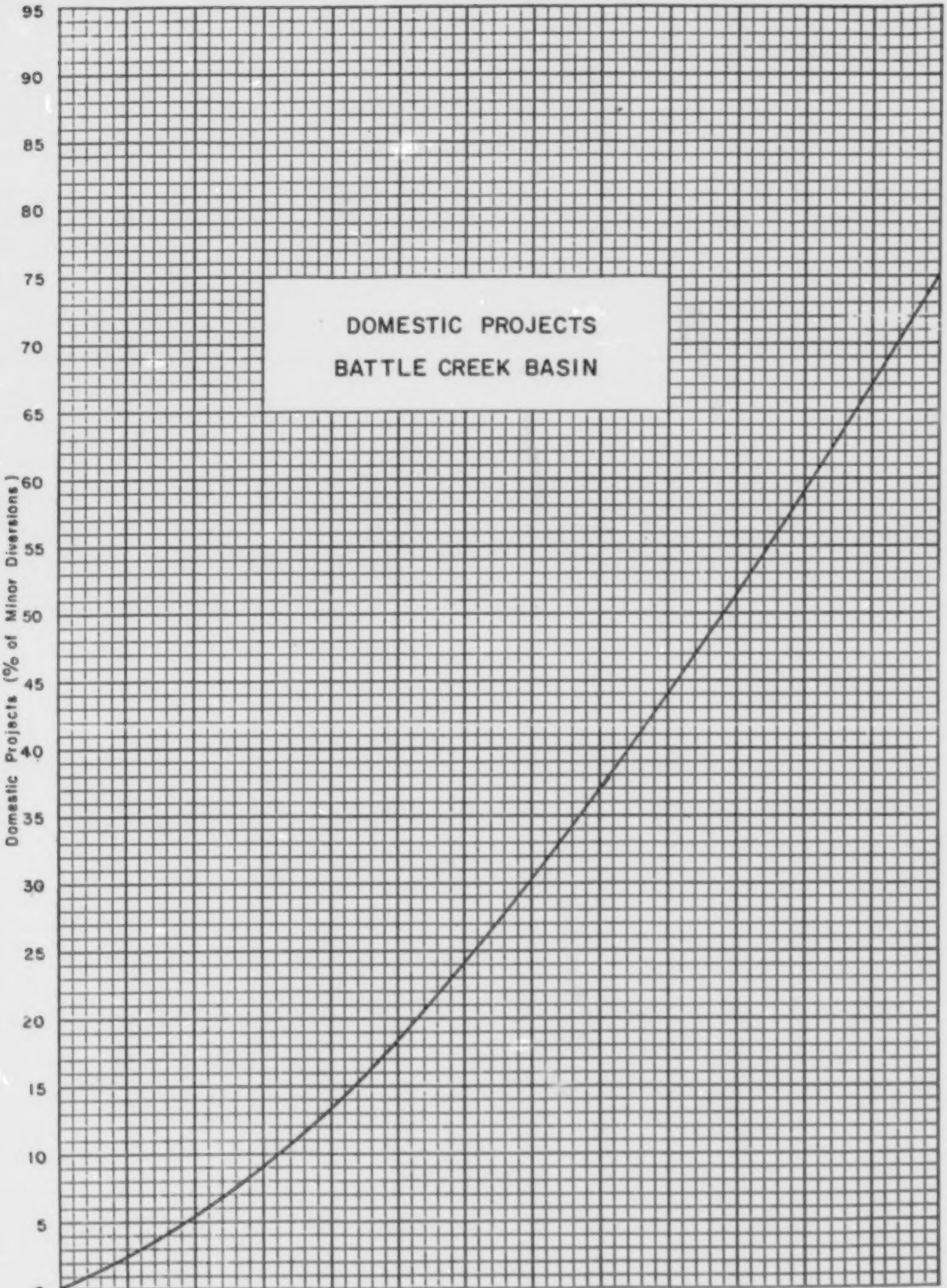
In an interim report (Spitzer, 1971), it was recommended that further monitoring of domestic project usage be discontinued and that no attempt be made to include the usage figures in natural flow computation; however, at the January 29, 1972 meeting of the Field Representatives, it was agreed that domestic project usage figures be included in the computations but that no further monitoring of index domestic projects be made. Rather, total minor diversions would be used as the basis for domestic project usage calculations. This decision was reached as a definite relationship was apparent between total minor diversions and domestic project usage but no relationship existed between natural flow and domestic project usage for either basin. Thus, it was agreed to use domestic project usage as a percentage of the total minor diversions.

These values are estimated as follows:

Frenchman River
Domestic usage is 45 percent of minor diversions

Battle Creek
Domestic usage is a varying percentage of minor diversions as shown on the graph on page 6.14.

Lodge Creek
Domestic usage is a very small percent of the natural flow, therefore, no estimate is made for domestic usage.


DOMESTIC PROJECTS
BATTLE CREEK BASIN
Domestic Projects (% of Minor Diversions)
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
Minor Diversions (100's cubic decametres)

6.2.5 Channel Losses

The application of channel losses falls into the following two general categories:

(a) Losses which would have occurred in the natural state to water which is stored in reservoirs or diverted for irrigation in Canada.

(b) Losses to water which is released to the stream from existing reservoirs or which is returned to the stream from irrigated land.

The channel loss function that is applied to flow depletions and return flows consists of a loss constant and a variable loss factor to reflect seasonal variations in channel losses. The channel loss formula is:

$$L = KD + P(|Q| - KD)$$

where:
L is gross potential channel loss in cubic decametres over period D,
D is number of days in the flow period (10 or 11 days),
K is loss constant in dam^3/day for a particular river reach,
P is variable loss factor for a particular river reach and season,
Q is gross flow depletion, that is, total depletion less return flow for a particular river reach (dam^3).

Note that to facilitate computations, channel losses are applied to the entire 10-day period and not just the days of flow, diversion, storage, or release.

6.2.5.1 Frenchman River Basin Loss Factors

Cypress Lake Area
Loss Constant K = 14.7 dam^3/day (6 cfs/day)

Period	Variable loss factor P
to Apr 1	.12
Apr 2 to May 1	.18
May 2 to Jun 1	.30
Jun 2 to Sep 1	.48
Sep 2 to Oct 1	.30
Oct 2 to Oct 22	.18

Eastend Area
Loss Constant K = 12.3 dam^3/day (5 cfs/day)

Period	Variable loss factor P
to Apr 3	.10
Apr 4 to May 3	.15
May 4 to Jun 3	.25
Jun 4 to Sep 3	.40
Sep 4 to Oct 3	.25
Oct 4 to Oct 24	.15

Val Marie Area
Loss Constant K = 4.92 dam^3/day (2 cfs/day)

Period	Variable loss factor P
to Mar 28	.04
Mar 29 to Apr 27	.06
Apr 28 to May 28	.10
May 29 to Aug 28	.16
Aug 29 to Sep 27	.10
Sep 28 to Oct 28	.06

The channel loss function for the Frenchman River was developed in 1961 based on the report by Collier (1960) and on hydrometric records for the period 1940-60. The channel loss function was further substantiated in a report by Cuthbert and Langley, (1974) which examined hydrometric records for the period 1951-70.

6.2.5.2 Battle Creek Basin Loss Factors

Because of the high ground water contribution in the Battle Creek basin, the variable loss factor is considered to be 0 per cent. The loss constants (K) are as follows:

Reesor Lake Area = 14.7 dam^3/day (6 cfs/day)
Gaff Ditch Area = 9.76 dam^3/day (4 cfs/day)
Cypress Lake Area = 7.34 dam^3/day (3 cfs/day)
Consul Area = 4.92 dam^3/day (2 cfs/day)
Nashlyn Area = 2.42 dam^3/day (1 cfs/day)

The channel loss function for Battle Creek is based on intensive channel loss studies (McFarlane, 1924; McGavin, 1925) carried out during the period 1922-24 and verified by records obtained in the 1960s; however, channel losses were not included on Battle Creek until 1971 when agreement was reached on the values to be used.

6.2.5.3 Lodge Creek Basin Loss Factors

Upper Lodge Area
Loss Constant K = 7.34 dam^3/day (3 cfs/day)

Period	Variable loss factor P
to Mar 27	.06
Mar 28 to Apr 26	.09
Apr 27 to May 27	.15
May 28 to Aug 27	.24
Aug 28 to Sep 26	.15
Sep 27 to Oct 27	.09

Cressday, Mitchell, and Middle Creek Reservoir Area
Loss Constant K = 4.92 dam^3/day (2 cfs/day)

Period	Variable loss factor P
to Mar 28	.04
Mar 29 to Apr 27	.06
Apr 28 to May 28	.10
May 29 to Aug 28	.16
Aug 29 to Sep 27	.10
Sep 28 to Oct 28	.06

Jaydot and Altawan Reservoir Area
Loss Constant K = 2.42 dam^3/day (1 cfs/day)

Period	Variable loss factor P
to Mar 29	.02
Mar 30 to Apr 28	.03
Apr 29 to May 29	.05
May 30 to Aug 29	.08
Aug 30 to Sep 28	.05
Sep 29 to Oct 29	.03

Channel losses were first applied to Lodge Creek in 1963 (ref. annual IJC Reports). The channel loss function for Lodge Creek is believed to be based on the results of the channel loss studies conducted in the Frenchman River basin; however, documentation confirming this was not found. G.H. Morton, Field Representative for Canada believes that the Lodge Creek channel loss functions were developed from an examination of early 1960s flow records from stations located in the Lodge Creek basin; however, documentation is again lacking.

6.2.6 Return Flows

A certain amount of the water diverted to irrigation projects eventually returns to the main channel. The amount of water diverted for use in the major irrigation projects is measured and the surface water return flow from the project is either measured or estimated as a percentage of the volume diverted. No return flows are applied to minor diversions as minor diversions are usually very efficient in the use of available water supplies.

In the case of diversion from Battle Creek, a lag time is applied between the time of diversion and the time the return flow enters the channel. For the Frenchman River it is assumed that the diversion and subsequent return flow occur within the same ten-day period. For Lodge Creek return flows from major projects are measured. In all basins return flow coefficients may be modified if conditions warrant.

6.2.6.1 Frenchman River Basin Return Flow Coefficients

Diversion	Return Flow (%)
Eastend Canal	25
Huff Lake Gravity Canal	25
Newton Lake Main Canal	25

The return flow percentage was developed in a report by Johnson (1975). At the January 27, 1976 meeting of the Field Representatives, it was agreed that the return flow percentage of 25 would normally be used at all times.

6.2.6.2 Battle Creek Basin Return Flow Coefficients

Diversion	Lag Time (Days)	Return Flow (%)
Gaff Ditch	0	35*
Vidora Ditch	4	25**
Richardson Ditch	2	25**
McKinnon Ditch	2	25**
Nashlyn Ditch	2	25**

*The return flow ratio of 0.35 was developed in a report by Johnson, (January, 1977) and was first used in the 1977 natural flow computations.

**Adjusted if record from stations Battle Creek near Consul or Battle Creek below Nashlyn Project indicate unusual return flow conditions. See section 6.6.3 for examples of the Consul and Nashlyn return flow calculation.

6.2.7 Lodge Creek Basin Return Flows

Diversion	Return Flow Measured At
Bedford Outlet	Walburger Coulee (see section 6.7.1.3)
Spangler Ditch	Squaw Coulee (see section 6.7.3)

6.3 EXCESS AND DEFICIT FLOWS

According to the 1921 Order of the International Joint Commission, the natural flow of the eastern tributaries is to be divided equally between Canada and the United States but the Order is not very explicit on the accounting procedure for excess or deficit flows in any given period. As a result the following procedure has evolved: deficit flows carry over from one period to another, are cumulative, and must be made up by subsequent excess flows. Excess flows do not carry over from one period to another, are not cumulative, and cannot be used to make up future deficits. This ensures a more equitable division of flow throughout the year.

If the United States does not receive 50 percent of the natural flow during any ten day period, the difference between 50 percent of the natural flow and the actual amount received is a deficit in delivery. The United States is entitled to request that a deficit be refunded in the next ten-day period or conversely, Canada is entitled to refund a deficit in the next ten-day period; however, experience in the 1980s has shown that it is often beneficial to both countries for Canada to store more than its share during early spring runoff, thereby creating a deficit in deliveries to the United States The deficit can then be refunded during the irrigation periods after spring runoff. This method of operation benefits Canada by maintaining a higher head on the inlets to the irrigation canals, and allows the use of irrigation return flows to make up a portion of the deficit. It also benefits the United States by reducing the flood hazard in spring and provides higher flow for the post-spring runoff irrigation.

This method of operation does have some problems for Canada in that channel losses are lower in spring than in summer. Therefore for a given quantity of water stored in the spring a greater quantity of water must be delivered in summer. Recognizing this, Canadian water management agencies (PFRA and Sask Water) generally make releases from reservoirs when channels are primed and channel losses are at a minimum.

The 1921 Order, Article VIII, section (b) states that "...Irrigation officers are... authorized and directed... to operate the irrigation works of either country in such a manner... to secure to the two countries the greatest beneficial use thereof". One example of referral to this clause occurred in the fall of 1986. There had been several years of drought in this area and the reservoirs were quite depleted. September, 1986 happened to be very wet and negotiations were held between WRB, the USGS, and Sask Water regarding retaining runoff from the rainstorms. The USGS stated that they did not require the water and they agreed to having Canada store the runoff, go into deficit, and Canada would not have to make up the deficit that year. This would allow the water to be used in 1987 which would be of benefit to both countries. This was a precedent setting action and further negotiations were to occur in the following months to deal with how the water carried over from 1986 would be shared in 1987. This question became irrelevant, however, when the rainstorms turned into a flood and there was too much water for everyone. No further discussions regarding carrying over a deficit from one year to the next have taken place since then and no guidelines or procedures have been established. For now, it appears that future incidents will be handled on an ad hoc basis by the Field Representatives.

6.3.1 Artificial Deficits

A problem with the fixed division periods occurs when a substantial rainfall or reservoir release overlaps a division period. For these types of events and because average times of travel are used to lag division periods, an artificial deficit may occur. For example in 1978 a 75 mm rainfall occurred between September 10 and 12, thus overlapping the division period for Cypress Lake diversions. Using the recorded data and the standard division periods, an overdelivery occurred for the September 5-14 period and an equivalent artificial deficit was created for the September 15-24 period. This problem was discussed at the January 31, 1979 meeting of the Field Representatives and it was agreed that the flows for the two periods would be combined. It was further agreed that anomalies of this nature will be considered by the Field Representatives for both countries on an ad hoc basis.

6.4 FIELD PROCEDURES

6.4.1 Field Schedules

Each year at the annual records conference the USGS presents a schedule delineating when they will be visiting the international stations in Canada. The USGS does most of the field work for the boundary stations during spring runoff because of difficult access from the Canadian side during the spring period. Generally, after spring runoff, the USGS visits international stations in the Lodge and Battle Creek basins once per month, and in the Frenchman River basin only once for the rest of the season. The visit to the Frenchman River basin is usually made in the summer during the vacation period of the WRB personnel.

The Procedural Guide for International Gauging stations (1st edition, March 1985) states that "where possible... a minimum of three visits annually" should be made by field officers to international gauging stations in the other country. The travel distance for the USGS to the Frenchman basin is quite long therefore an arrangement has been in place where the USGS will visit the Lodge and Battle basins more frequently in lieu of the visits to the Frenchman River basin.

Time and access permitting, WRB voluntarily undertakes a water quality sampling trip to the International Boundary stations at month-end, and at that time WRB will also do the hydrometric work. A combined water quality and hydrometric trip to the boundary stations at high water would take about three days. In the high water conditions of spring runoff, during busy irrigation periods, or during high summer rainstorm events, water quality sampling may not be completed due to the priority of collecting hydrometric data. If possible, Water Quality Branch should be informed beforehand if the normal sampling schedule cannot be met. All trips are coordinated with the USGS to eliminate any redundant trips.

6.4.2 Border Crossing Privileges

Servicing the hydrometric gauging stations at the International Boundary often requires the crossing of the boundary at uncontrolled points. Special border crossing privileges have been granted by American and Canadian government agencies to the USGS and WRB for servicing the boundary stations. These privileges require that the hydrometric technologist follow special check-in procedures with Canada Customs, the U.S. Customs Service, and the U.S. Border Patrol. Refer to Appendix F for details on the procedures.

6.4.3 PFRA Pasture Access

Servicing of hydrometric gauging stations in the eastern tributaries occassionally requires access to PFRA pastures. The PFRA has granted right-of-entry permits to WRB personnel. Field crews are to contact the pasture managers prior to each entry onto the pastures and must be prepared to produce identification when requested by any PFRA employee while on pasture lands. Complete details on the pasture access procedure are outlined in the IWD Regina central registry file 1375-1.

6.5 FRENCHMAN RIVER BASIN SPECIAL COMPUTATION AND FIELD PROCEDURES

6.5.1 Cypress Lake

Before its development as a reservoir, Cypress Lake was an in-land drainage basin (see figure page 6.26) fed by numerous small coulees and two principal tributaries, Sucker and Oxarat Creeks. Belanger Creek, the uppermost tributary of the Frenchman River, rising about nineteen kilometres directly north of the lake, skirts the lake near the east end and joins the Frenchman River shortly thereafter.

In 1938 Cypress Lake was converted into a reservoir by dams placed near each end of the old natural lake. Diversion canals carry water during the runoff periods from Battle Creek into the west end and from Belanger Creek into the east end of the reservoir. Outlet canals are also provided at either end of the reservoir. Figures on pages 6.27 and 6.28 show the canal system at the east and west ends of Cypress Lake.

6.5.2 Belanger Creek Diversion to Cypress Lake - 11AC064

The purpose of this station is to quantify the diversion from Belanger Creek to Cypress Lake and area. There are several drains along this canal that are used to flood hay land adjacent to the canal. One of the drains is located between the gauge and the diversion headworks. Measurements should be made below this drain whenever possible. During high water, measurements may have to be made at the highway bridge (about 500 m downstream). If so, any diversion between the gauge and the bridge must be added to the measurement in order to arrive at a total flow passing the gauge.

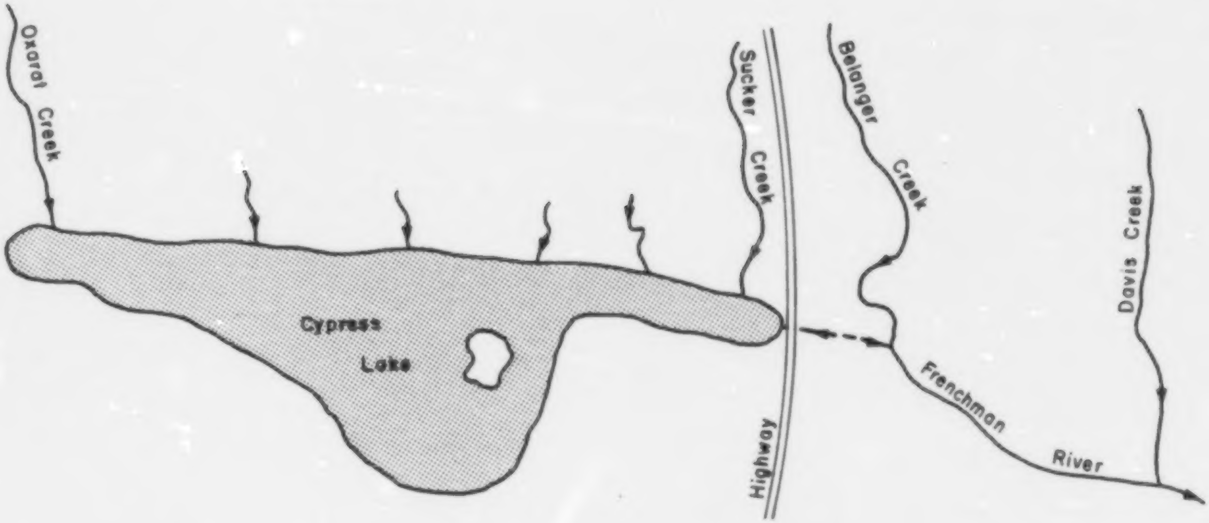
6.5.3 Cypress Lake East Outflow Canal - 11AC060

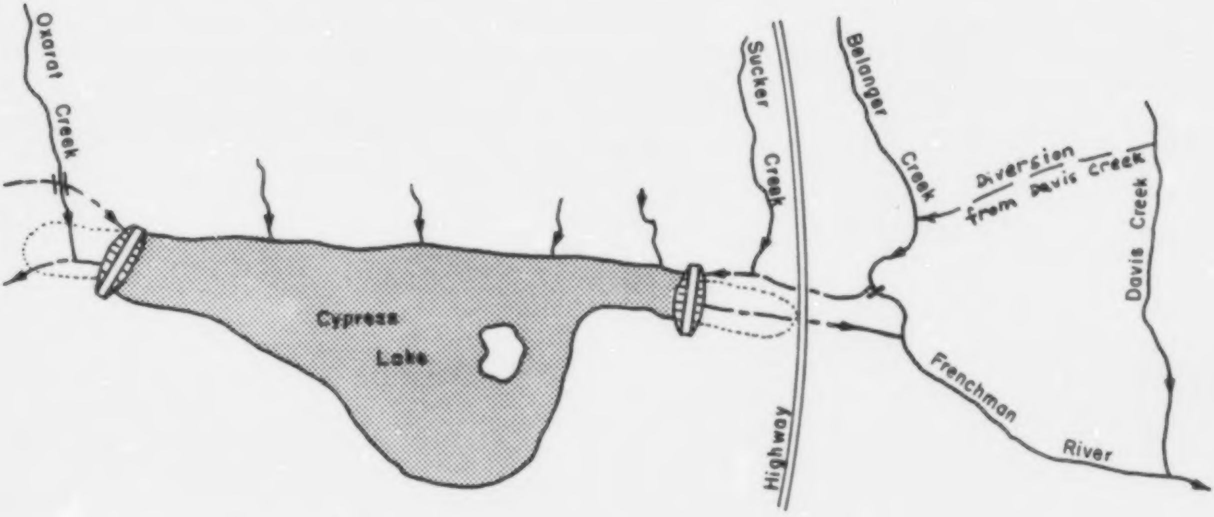
This station measures return flow from irrigation projects directly to the east of Cypress Lake and releases from Cypress Lake. Water is held on the irrigation projects, as a rule, until late May to about mid-June and then released. It is important to obtain measurements during this release because the stage-discharge relationship is poorly defined and often there is backwater from Belanger Creek.

In the mid-1980s the irrigator constructed drainage ditches through the irrigation projects parallel to the East Outflow Canal and draining to Belanger

DEVELOPMENT OF CYPRESS LAKE

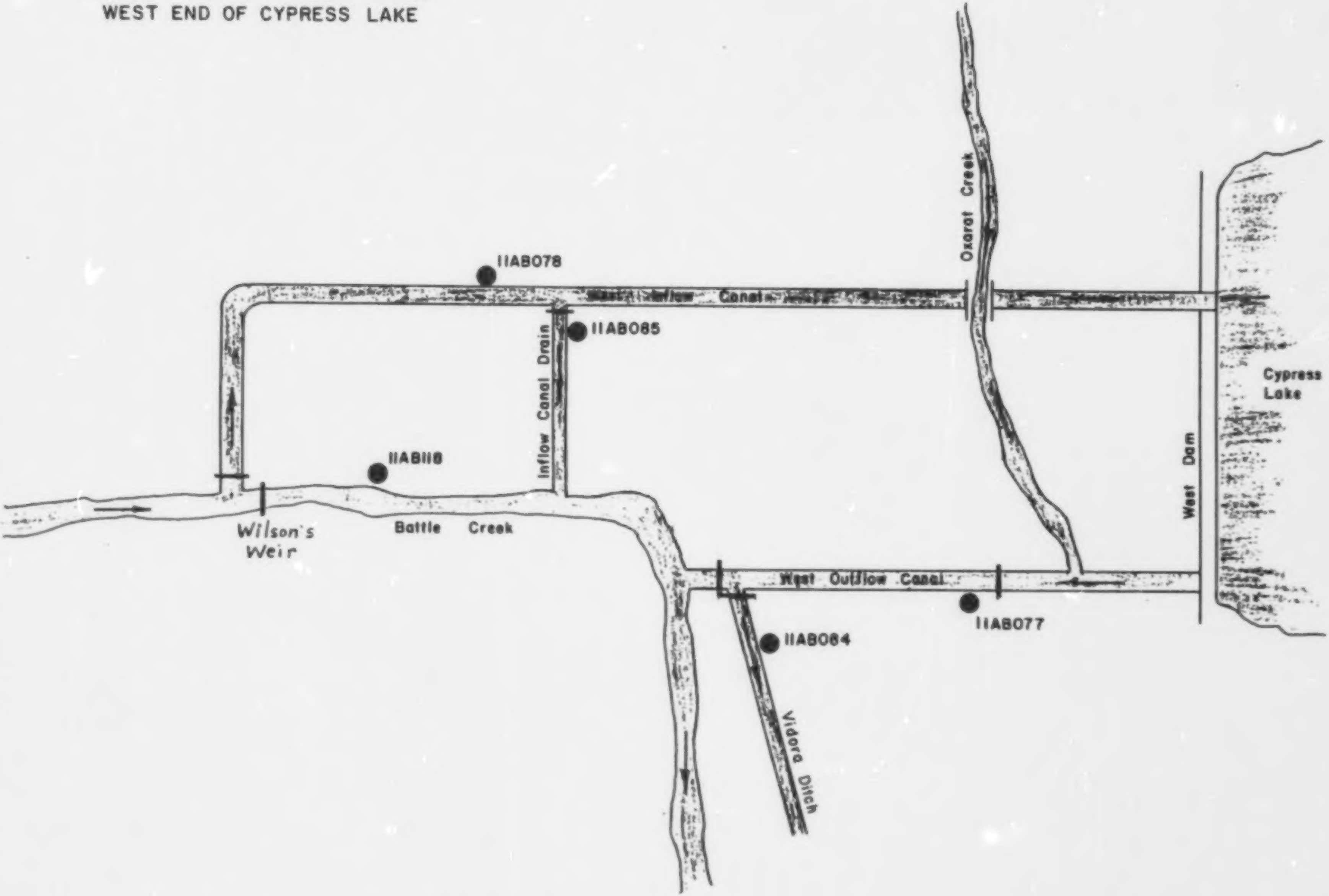
CYPRESS LAKE TO 1938


Oxarat Creek
Sucker Creek
Belanger Creek
Davis Creek
Cypress Lake
Highway
Frenchman River

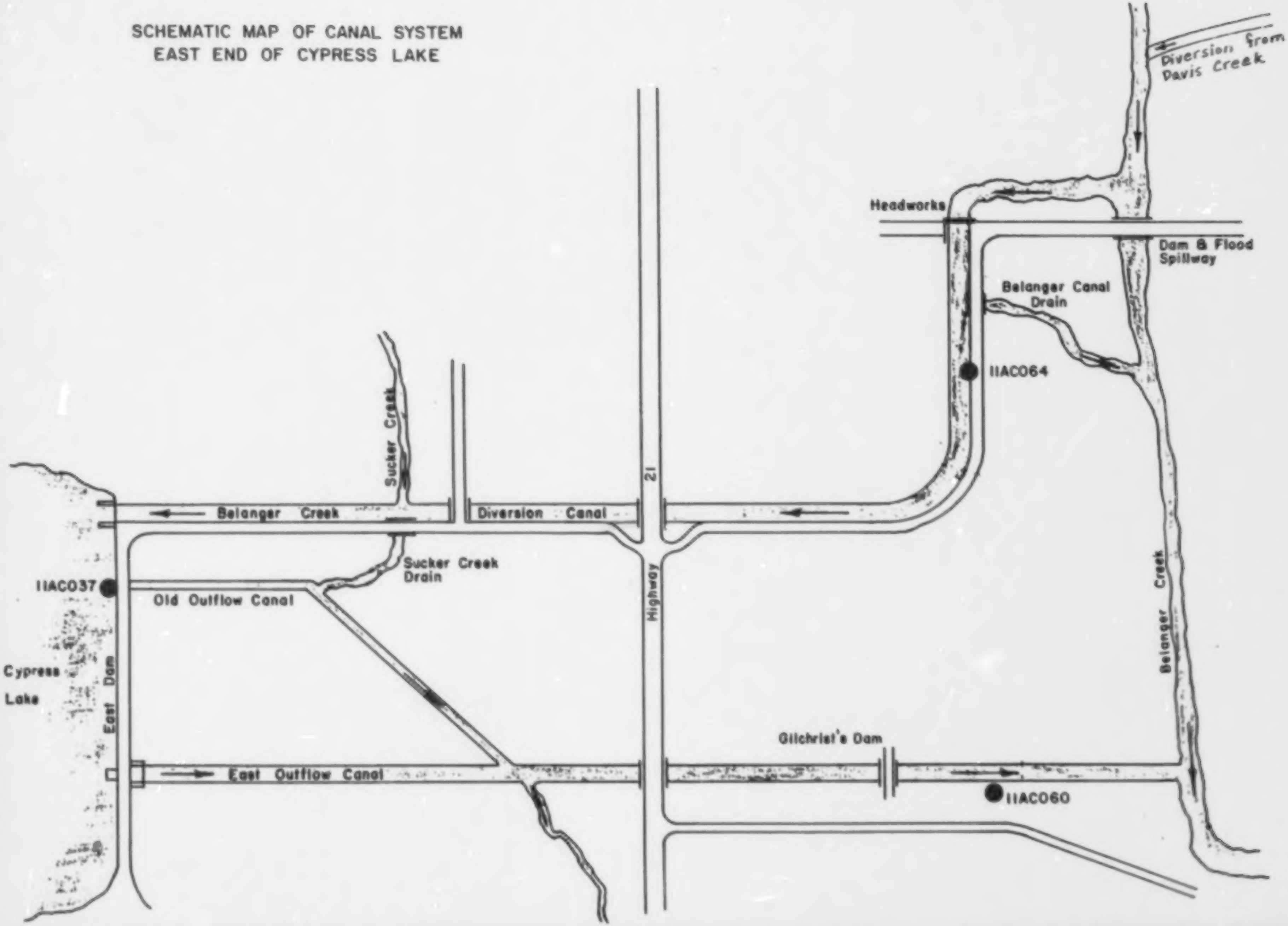

Oxarat Creek
Sucker Creek
Belanger Creek
Diversion from Davis creek
Davis Creek
Cypress Lake
Highway
Frenchman River

CYPRESS LAKE FROM 1939

SCHEMATIC MAP OF CANAL SYSTEM
WEST END OF CYPRESS LAKE


IIAB078
West Inflow Canal
Oxarat Creek
IIAB085
Inflow Canal Drain
Cypress Lake
West Dam
IIAB118
Wilson's Weir
Battle Creek
West Outflow Canal
IIAB077
IIAB084
Vidora Ditch

SCHEMATIC MAP OF CANAL SYSTEM EAST END OF CYPRESS LAKE


Diversion from Davis Creek
Headworks
Dam & Flood Spillway
Belanger Canal Drain
11AC064
Sucker Creek
Belanger Creek
Diversion Canal
21
Highway
Sucker Creek Drain
11AC037
Old Outflow Canal
Cypress Lake
East Dam
Gilchrist's Dam
East Outflow Canal
11AC060
Belanger Creek

Creek. The purpose of the ditches is to drain the low portions of the irrigated area. The ditches are to be operated such that the majority of the irrigated area is drained into the East Outflow Canal with only the lower areas being drained directly into Belanger Creek; however, it is possible that all the irrigated area can be drained via the new ditches. Sask Water officials have asked the irrigator to avoid this if possible as any flow down the new ditches bypasses the East Outflow Canal station and Canada does not receive any credit for the return flow.

6.5.4 Eastend Canal near Eastend - 11AC052

The stage-discharge relationship is influenced by check structures downstream. Discharge measurements are essential to determine shift corrections.

6.5.5 Frenchman River below Newton Lake - 11AC062

This is a conventional stage-discharge station. There is a frost floor stored under the recorder shelf which is installed in fall and keeps the well open. The frost floor must be removed prior to any large release from the lake.

6.5.6 Val Marie Pump No. 1 - 11AC068

Due to the small quantity of water diverted at this station, the Field Representatives decided at the February 2, 1983 International Records Conference to treat Val Marie Pump No. 1 as a minor diversion. The 25 percent return flow factor should still be applied to the diversion.

This station has an H-flume to measure the discharge and metering is not necessary as long as the flume is not affected by backwater (which has never occurred in the station's history). The outside gauge plate is fastened directly to the H-flume with 0.000 m = 0 flow. No level checks are required. To set the recorder pen when there is no flow, pour water into the well to bring it up to the zero flow point. At this point the gauge height = 0.000 m. Read the gauge height at the piezometer tube when there is flow. Clean out float well when necessary to prevent piezometer from plugging.

6.5.7 Val Marie Pump No. 2

Due to the small quantity of water diverted at this station, the Field Representatives decided at the January 28, 1981 International Records

Conference to treat Val Marie Pump No. 2 as a minor diversion. The 25 percent return flow factor should still be applied to the diversion.

This pump is used to pump water from the Frenchman River about midway between Huff Lake and Newton Lake. The pump is equipped with a Saskatchewan Power Corporation (SPC) watt-hour meter to record the power consumption. Records are obtained by relating the kilowatt hours (kwh) used by the pump to an established consumption figure for the pump.

The kwh meter should be read once prior to irrigation (about April 1) and after irrigation is complete (about September 1). Read the first five dials on the meter to obtain a five digit number. An example of the method of calculation follows.

```
SPC meter reading on Apr. 1, 1986 = 01865 kwh
SPC meter reading on Oct. 9, 1986 = 02862 kwh
        Total power used          =   997 kwh
```

The formula to compute the diversion is:
Total power / conversion factor = diversion

The conversion factor has been developed from historical records and is: 25 kwh of power is required to pump 1 dam^3 of water.

Therefore: 997 kwh / 25kwh/dam^3 = 40 dam^3

A return flow factor of 25 percent must be applied to this diversion

Therefore: 40 dam^3 X 0.25 = 10 dam^3
The actual diversion = 40 dam^3 - 10 dam^3 = 30 dam^3

6.5.8 Huff Lake Pumping Canal - 11AC066

This station records the number and times of the operation of two diesel pumps used for irrigation. A stage-discharge relationship is not used and level checks are not necessary. The pumps may be operated individually or simultaneously and the discharge varies with the reservoir elevation. A record of Huff Lake elevations, pump operations, and discharge measurements are required to compute daily discharges. Experience has shown that a pump-discharge rating provides more reliable data than a canal stage-discharge rating, therefore, the stage recorder on the canal is used only to determine the number of pumps (one or two) operating and the hours of operation.

The following procedure is used to compute daily discharges:

1. Based on the discharge measurements, plot a reservoir elevation versus discharge curve for one pump operation and a similar curve for two pump operation.

2. From the reservoir elevation-discharge curves, make up the corresponding rating table.

3. Determine the shift of each measurement from the curve. Note that this shift is a discharge shift and not a stage shift.

4. On a daily basis determine the number of hours of one pump and two pump operation and the mean reservoir elevation for each period of steady flow. Using the mean reservoir elevation, determine the discharge from the rating table for each period. Apply the appropriate shift correction to this discharge. The shift for one pump operation is assumed to be half the shift for two pump operation.

5. Compute the daily discharge based on the discharge for each steady flow period and the number of hours in each state. The time of operation is rounded to the nearest whole hour.

The table on the following page is used to tabulate these computations for both the interim and final reports.

HUFF LAKE PUMPING CANAL NEAR VAL MARIE - 11AC066

19__

1	2	3	4	5	6	7	8	9
Date	No. of Pumps	Reservoir Elevation	Q	Q shift	Q used	No. of hours	Total Q	Daily Q
	observed	observed	from table	computed	4 + 5	observed	6 X 7	computed

COMPUTED BY: **DATE:**	**CHECKED BY:** **DATE:**

6.5.9 Huff Lake Gravity Canal - 11AC065 and Newton Lake Main Canal - 11AC054

Weed growth and the manipulation of checkboards in the canals downstream from the stations cause highly varying backwater conditions which make it extremely difficult to compute the discharge by a conventional stage-discharge relationship. In order to overcome the computational problems associated with varying backwater conditions the submerged orifice equation was adopted to compute the discharge as follows:

$$Q-CA\sqrt{2gh}$$

where Q is the discharge (m^3/s)
C is the coefficient of contraction
A is the area of the gate opening (m^2)
g is the acceleration due to gravity ($9.8\ m/s^2$)
h is the differential head between the water surfaces of the reservoir and canal (m)

Automatic recorders on the canal and reservoir record their respective elevations which are then used to determine the differential head, h. An automatic recorder is installed to record changes in gate opening. Field measurements of the gate opening are taken by measuring from the top of the collar on the large horizontal gear to the bottom edge of the stop piece at the top of the threaded stem. The discharge in the canal is measured on a regular basis to develop a relationship between the gate opening and the combined factor CA.

The following seven steps are followed to compute flows on the canals:

1. Record gate opening, reservoir elevation and canal elevation corresponding to each discharge measurement.

2. Based on the above information, compute CA for each measurement from the formula.

3. Plot gate opening versus CA for each measurement and draw a smooth curve.

4. From the gate opening vs CA curve, make up a gate opening vs CA table.

5. Determine the shift of the measurement from the gate opening versus CA curve.

6. On a daily basis determine the canal elevation and reservoir elevation for each gate setting and the number of hours at each setting. Apply the shift correction to the gate opening to obtain the effective gate opening and use this value and the gate opening vs CA curve to determine CA.

7. Compute the discharge at each gate setting and the daily discharge based on the number of hours at each setting.

An example of this procedure follows.

EXAMPLE : Huff Lake Gravity Canal

$$Q=CA\sqrt{2gh}$$
$$Q=0.879(measurement)$$
$$h=res.\ elev.-canal\ elev.$$
$$=815.638-813.556$$
$$0.879=CA\sqrt{2\times9.8\times2.082}$$
$$\therefore CA=0.879\div6.388=0.138$$

From table of **gate opening vs CA**
Gate opening (G.O.) (measured) = 0.399
Gate opening (from table) = 0.189
Therefore **shift to gate opening** = -0.210
If G.O. (measured) > G.O. (table), shift is negative.
If G.O. (measured) < G.O. (table), shift is positive.

The **shift to gate opening** is then applied to the gate openings determined from the chart record producing **effective gate openings**. Values of CA are then determined from the table for each effective gate opening.

The table on page 6.37 is used to tabulate these computations for the interim reports. For the final computations an automated computer procedure is used. The procedure generates an annual listing and output in WRB record format 79-041. Instructions for the computer procedure follow.

NOTE: at time of writing (May, 1991) the CANAL program was in the process of being re-written to run on the MicroVax II mini-computer at WRB, Regina. The following instructions are for the PDP 11/44 and Westbridge computer programs.

CANAL COMPUTER PROGRAM

1. INPUT

1.1 Canal Stations

11AC054	Newton Lake Main Canal
11AC065	Huff Lake Gravity Canal

These stations are run on the HOURLY program for water levels, therefore the following data must be input:

gauge corrections
digitizing

1.2. Lake Stations

11AC056	Newton Lake
11AC063	Huff Lake

These stations are run on the HOURLY program for water levels, therefore the following data must be input:

gauge corrections
digitizing

1.3. Headgate Recorders

81AC056	Newton Lake Headgate
81AC063	Huff Lake Headgate

These stations are run on the HOURLY program for discharges (CA values), therefore the following data must be input:
CA vs. gate opening table
gauge corrections
shift to gate opening corrections
digitizing

2. To access the canal program, key in @W1 on the WRB, Regina mini-computer.

3. Select Regional Applications.

4. Follow the prompts for the CANAL program. You will be prompted for the canal station, reservoir station, and headgate station numbers. They must be entered in this order.

5. Daily discharges will be generated with each run.

6. Plots are done manually.

VAL MARIE

____

19__

1	2	3	4	5	6	7	8	9	10	11	12
Date	Canal Elev.	Res. Elev.	Net Head	$\sqrt{2gh}$	Gate Opening	Shift to G.O.	Effective G.O.	CA	Q	Hours	Mean Daily Q
			3-2				6+7		5 X 9		

COMPUTED BY: ________________ DATE: ____________

CHECKED BY: ________________ DATE: ____________

6.6 BATTLE CREEK BASIN SPECIAL COMPUTATION AND FIELD PROCEDURES

6.6.1 Shepherd Ditch near Consul - 11AB020

This is a conventional stage-discharge station. The flows recorded at the station are included as an annual volume in the minor diversions for the Battle Creek basin. A 25 percent return flow factor should be applied to the diversion.

6.6.2 McKinnon Ditch near Consul - 11AB044

A rancher pumps from McKinnon Ditch upstream of the gauge. The pumpages must be added to the flows recorded at the McKinnon Ditch gauge. The pumpages are usually very low (about 0.06 to 0.24 m^3/s) and the rancher usually diverts for only 1 or 2 days. The pumpages should be metered but this is not always possible due to the short time of operation. If measurements cannot be made, the PFRA in Consul will have pumping rates and duration data. The exact times of pump startup and shutdown can be determined from the chart record for the McKinnon Ditch station.

6.6.3 Return Flow from Consul and Nashlyn Projects

Three stations are operated on Battle Creek to determine return flows from the Consul and Nashlyn irrigation projects:

- Battle Creek below Wilson's Weir (11AB118) and Battle Creek near Consul (11AB096) for the Consul projects
- Battle Creek near Consul (11AB096) and Battle Creek below Nashlyn Project (11AB101) for the Nashlyn projects.

The difference between flows at the upstream and the downstream station (with the appropriate time lag applied) is considered to be the return flow from each project. This method must be used with caution and careful judgment must be exercised. For example: rainstorm events between the upstream and downstream stations can indicate return flows exceeding 100 percent. In such an event, irrigation return flows must be estimated. An examination of return flows from previous years can be used to arrive at a reasonable return flow estimate. Following are blank forms used in the computations and examples of the computations done in 1985 and 1986.

DETERMINATION OF RETURN FLOW FROM CONSUL PROJECTS FOR 19___

	1	2	3	4	5	6	7	8	9	10	11	12
Period Battle Creek near Consul	Battle Creek below Wilson's Weir 1 Day Lag	Cypress Lake West Outflow Canal 1 Day Lag	Total Flow Above Consul Projects	Channel Loss to Consul	Gross Flow at Consul	Vidora Ditch	Richardson Ditch	McKinnon Ditch	Total Diversion	Net Flow at Consul	Battle Creek at Consul	Return Flow
	Measured	Measured	1+2	$0.028 m^3/s$ /day	3-4	Measured	Measured	Measured	6+7+8	5-9	Measured	11-10
									Σ=			Σ=

PERCENT DIVERSION = $\frac{\Sigma \text{ column 12}}{\Sigma \text{ column 9}}$ X 100 = ——— X 100 = %

COMPUTED BY:

DATE:

CHECKED BY:

DATE:

DETERMINATION OF RETURN FLOW FROM NASHLYN PROJECTS FOR 19___

	1	2	3	4	5	6	7
Period Battle Creek below Nashlyn Project	Battle Creek near Consul 1 Day Lag	Nashlyn Canal 2 Day Lag	Battle Creek below Nashlyn Weir	Channel Loss Consul to Nashlyn	Expected Flow at Battle below Nashlyn	Battle Creek below Nashlyn Project	Return Flow
	Measured	Measured	1-2	$0.028 m^3/s/day$	3-4	Measured	6-5
		Σ=					Σ=

PERCENT DIVERSION = $\frac{\Sigma \text{ column } 7}{\Sigma \text{ column } 2}$ X 100 = ---------- X 100 = %

COMPUTED BY:	CHECKED BY:
DATE:	DATE:

Example 1: 1985 RETURN FLOWS

1. DETERMINATION OF RETURN FLOW FOR CONSUL PROJECTS

(computations are on page 6.42)

The following basic assumptions were made:

a) Travel (lag) time from Battle Creek below Wilson's Weir (11AB118) to Battle Creek near Consul (11AB096) is 1 day.
b) Travel time for return flow from Vidora Ditch is 4 days.
c) Travel time for return flow from Richardson Ditch is 2 days.
d) Travel time for return flow from McKinnon Ditch is 2 days.

Summary

The return flow calculations for 1985 indicate a return flow of 17.5 percent for the irrigation period, which appears to be reasonable, since the spring snow cover was well below normal, and the soil moisture content at the beginning of the irrigation season would indicate a lower than normal return flow. It was recommended that a return flow factor of 17 percent be used rather than the normal 25 percent.

2. DETERMINATION OF RETURN FLOW FOR NASHLYN PROJECT

(computations are on page 6.43)

The following basic assumptions were made:

a) Travel (lag) time from Battle Creek near Consul (11AB096) to Battle Creek below Nashlyn Project (11AB101) is 1 day.
b) Travel time for return flow from Nashlyn Canal is 2 days.

The return flow calculations indicate a return flow factor of 3.3 percent. It was recommended that 4 percent be used rather than the normal 25 percent.

Note that the period from April 2 to April 11 was included because no water was stored in the small reservoir below the Nashlyn Canal gauge as is the normal case.

DETERMINATION OF RETURN FLOW FROM CONSUL PROJECTS FOR 1985

	1	2	3	4	5	6	7	8	9	10	11	12
Period Battle Creek near Consul	Battle Creek below Wilson's Weir 1 Day Lag	Cypress Lake West Outflow Canal 1 Day Lag	Total Flow Above Consul Projects	Channel Loss to Consul	Gross Flow at Consul	Vidora Ditch	Richardson Ditch	McKinnon Ditch	Total Diversion	Net Flow at Consul	Battle Creek at Consul	Return Flow
	Measured	Measured	1+2	$0.028 m^3/s$ /day	3-4	Measured	Measured	Measured	6+7+8	5-9	Measured	11-10
May 3-12	24.1	0	24.1	0.3	23.8	0	0	0	0	23.8	24.0	0.2
May 13-23	22.0	8.8	30.8	0.3	30.5	4.9	3.9	0.5	9.3	21.2	14.6	0
May 24-Jun 2	14.6	11.1	25.7	0.3	25.4	11.7	6.3	5.7	23.7	1.7	4.5	2.8
Jun 3-12	10.9	13.2	24.1	0.3	23.8	8.5	8.5	6.6	23.6	0.2	3.7	3.5
Jun 13-22	6.1	17.3	23.4	0.3	23.1	3.5	1.9	8.1	13.5	9.6	9.7	0.1
Jun 23-Jul 2	3.5	14.8	18.3	0.3	18.0	9.0	0	0.1	9.1	8.9	14.2	5.3
Jul 3-12	1.9	8.3	10.2	0.3	9.9	0.2	0	0	0.2	9.7	10.9	1.2
									Σ=79.4			Σ=13.1

PERCENT DIVERSION = $\frac{\Sigma \text{ column } 12}{\Sigma \text{ column } 9} \times 100 = \frac{13.1}{79.4} \times 100 = 16.5\%$

COMPUTED BY: D.L. Turgeon	CHECKED BY: J.W. Stadnyk
DATE: January 17, 1986	DATE: January 17, 1986

DETERMINATION OF RETURN FLOW FROM NASHLYN PROJECTS FOR 1985

	1	2	3	4	5	6	7
Period Battle Creek below Nashlyn Project	Battle Creek near Consul 1 Day Lag	Nashlyn Canal 2 Day Lag	Battle Creek below Nashlyn Weir	Channel Loss Consul to Nashlyn	Expected Flow at Battle below Nashlyn	Battle Creek below Nashlyn Project	Return Flow
	Measured	Measured	1-2	$0.028 m^3/s/day$	3-4	Measured	6-5
April 4-13	12.0	5.6	6.4	0.3	6.1	4.1	0
April 14-23	20.6	8.5	12.1	0.3	11.8	7.6	0
April 24-May 3	30.9	3.0	27.9	0.3	27.6	25.5	0
May 4-13	24.0	0	24.0	0.3	23.7	21.7	0
May 14-24	14.6	6.3	8.3	0.3	8.0	6.8	0
May 25-Jun 3	4.5	1.0	3.5	0.3	3.2	4.0	0.8
		$\Sigma=24.4$					$\Sigma=0.8$

$$\text{PERCENT DIVERSION} = \frac{\Sigma\text{ column 7}}{\Sigma\text{ column 2}} \text{ X } 100 = \frac{0.8}{24.4} \text{ X } 100 = 3.28 \quad \%$$

COMPUTED BY: D.L. Turgeon	CHECKED BY: J.W. Stadnyk
DATE: January 17, 1986	DATE: January 17, 1986

Example 2: 1986 RETURN FLOWS

1. DETERMINATION OF RETURN FLOW FOR CONSUL PROJECTS

(computations on page 6.45)

The following basic assumptions were made:

a) Travel (lag) time from Battle Creek below Wilson's Weir (11AB118) to Battle Creek near Consul (11AB096) is 1 day.
b) Travel time for return flow from Vidora Ditch is 4 days.
c) Travel time for return flow from Richardson Ditch is 2 days.
d) Travel time for return flow from McKinnon Ditch is 2 days.

Summary

In 1986, significant flows were diverted down the Cypress Lake West Inflow Canal Drain during the periods May 13 to May 23, and May 24 to June 2. These flows had to be added to the flows at Wilson's Weir for these periods. Normally the flows from the drain are insignificant.

The return flow calculations for 1986 indicate a return flow of 24.4 percent for the irrigation period. This appears to be reasonable since spring rains and spring runoff resulted in near normal soil moisture content. It was recommended that the normal return flow factor of 25 percent be used.

2. DETERMINATION OF RETURN FLOW FOR NASHLYN PROJECT

(computations are on page 6.46)

The following basic assumptions were made:

a) Travel (lag) time from Battle Creek near Consul (11AB096) to Battle Creek below Nashlyn Project (11AB101) is 1 day.
b) Travel time for return flow from Nashlyn Canal is 2 days.

Summary

Conventional return flow calculations resulted in unreasonable return flows of 102 percent. The PFRA indicated that return flows for the Nashlyn Project appeared to be normal. The PFRA had noted, however, that several farmers had impounded runoff water in backflood projects and had released this water at various times. This additional water entered Battle Creek at several locations along with runoff from several snowstorms during March and April. These additional local inflows resulted in the unreasonable return flow percentage. As the PFRA indicated that return flows appeared to be normal, it was recommended that the normal return flow factor of 25 percent be used for 1986.

DETERMINATION OF RETURN FLOW FROM CONSUL PROJECTS FOR 1986

	1		2	3	4	5	6	7	8	9	10	11	12
Period Battle Creek near Consul	Battle Creek below Wilson's Weir 1 Day Lag		Cypress Lake West Outflow Canal 1 Day Lag	Total Flow Above Consul Projects	Channel Loss to Consul	Gross Flow at Consul	Vidora Ditch	Richardson Ditch	McKinnon Ditch	Total Diversion	Net Flow at Consul	Battle Creek at Consul	Return Flow
	Measured		Measured	1+2	$0.028 m^3/s/day$	3-4	Measured	Measured	Measured	6+7+8	5-9	Measured	11-10
	Wilson's Weir	Cypress Lake Drain											
May 13-23	0.1	5.4	7.7	13.2	0.3	12.9	0	1.9	2.0	3.9	9.0	4.1	0
May 24-Jun 2	0.1	9.9	32.2	42.2	0.3	41.9	1.9	12.0	11.8	25.7	16.2	16.5	0.3
Jun 3-12	2.3	0.1	23.1	25.5	0.3	25.2	12.0	1.2	2.3	15.5	9.7	15.5	5.8
Jun 13-22	2.6	0.1	16.7	19.4	0.3	19.1	10.9	0	0	10.9	8.2	13.9	5.7
Jun 23-Jul 2	1.7	0.1	5.8	7.6	0.3	7.3	6.2	0	0	6.2	1.1	4.5	3.4
										$\Sigma=62.2$			$\Sigma=15.2$

$$\text{PERCENT DIVERSION} = \frac{\Sigma \text{ column 12}}{\Sigma \text{ column 9}} \text{ X } 100 = \frac{15.2}{62.2} \text{ X } 100 = 24.4\%$$

COMPUTED BY: D.L. Turgeon	CHECKED BY: W.E. Slimmon
DATE: January 19, 1987	DATE: January 19, 1987

DETERMINATION OF RETURN FLOW FROM NASHLYN PROJECTS FOR 1986

	1	2	3	4	5	6	7
Period Battle Creek below Nashlyn Project	Battle Creek near Consul 1 Day Lag	Nashlyn Canal 2 Day Lag	Battle Creek below Nashlyn Weir	Channel Loss Consul to Nashlyn	Expected Flow at Battle below Nashlyn	Battle Creek below Nashlyn Project	Return Flow
	Measured	Measured	1-2	$0.028 m^3/s/day$	3-4	Measured	6-5
Mar 14-24	6.2	6.3	0	0.3	0	8.0	8.0
Mar 25 - Apr 3	16.8	6.1	10.7	0.3	10.4	16.9	6.5
April 4-13	8.3	2.6	5.7	0.3	5.4	9.4	4.0
April 14-23	1.4	0.1	1.3	0.3	1.0	4.0	3.0
May 25-Jun 3	16.5	5.1	11.4	0.3	11.1	10.7	0
Jun 4-13	15.5	0.9	14.6	0.3	14.3	13.9	0
		$\Sigma = 21.1$					$\Sigma = 21.5$

$$\text{PERCENT DIVERSION} = \frac{\Sigma \text{ column 7}}{\Sigma \text{ column 2}} \text{ X } 100 = \frac{21.5}{21.1} \text{ X } 100 = 102 \%$$

COMPUTED BY: D.L. Turgeon DATE: January 19, 1987	CHECKED BY: W.E. Slimmon DATE: January 19, 1987

6.7 LODGE CREEK BASIN SPECIAL COMPUTATION AND FIELD PROCEDURES

6.7.1 Middle Creek Reservoir - 11AB080

In 1982 a change in the computation procedure for Middle Creek was adopted as recommended in the report Middle Creek Reservoir Study (Herrington, 1982). In the former procedure, evaporation from Middle Creek Reservoir was a charge to Canada; however, the computed evaporation losses did not agree with the recorded reservoir storage changes during periods of negligible inflow and outflow. The procedure was replaced by a water balance approach using the inflow to Middle Creek Reservoir recorded at Middle Creek near Saskatchewan Boundary (11AB009), and outflow recorded at Middle Creek below Middle Creek Reservoir (11AB001) and Walburger Coulee below Diversions (11AB086).

There may be natural local inflow in the Middle Creek Reservoir area which is not recorded at the Middle Creek near Saskatchewan Boundary station (eg. from a localized rainstorm). The runoff from that event must be subtracted from the recorded flow at the outflow stations to determine return flow and "man-made" release from the Middle Creek Reservoir area. The natural local inflow is estimated by examining the hydrometric and meteorologic records.

6.7.1.1 Middle Creek Reservoir Bedford Outlet - 11AB114 There is no gauge at this station but the PFRA personnel operating the reservoir notify WRB when the gates are to be opened.

When releases are made, discharge measurements must be taken. Since gate settings are normally not changed during a release, the daily discharges can be interpolated between measurements.

Prior to about 1970 water was normally released through this outlet once a year to provide water for a Ducks Unlimited project and/or to irrigate the hayflats in the Bedford Slough. Water was also occasionally diverted to projects located on Walburger Coulee for irrigation and sometimes water was released through the outlet to replenish the water supply in Altawan Reservoir. In recent years these operations have not taken place as the Province of Saskatchewan is reluctant to release water that may flow back into Alberta. If releases from

Bedford Outlet are made, they are charged against Canada and the return flow, if any, is measured at the Walburger Coulee gauge. During the spring freshet and following rainfall events, the Walburger Coulee gauge is affected by natural runoff. This natural runoff must be estimated and subtracted from the recorded flow to determine the return flow from Middle Creek Reservoir releases.

6.7.1.2 Middle Creek Reservoir Flood Spillway - 11AB115 There is no gauge at this station and the discharge is determined from a reservoir elevation-discharge relationship. Because the reservoir seldom spills it is very important that discharge measurements be obtained when the reservoir is spilling.

6.7.1.3 Walburger Coulee below Diversions - 11AB086 For reasons discussed previously, return flows at this station have been minimal. At the January 31, 1979 meeting of the Field Representatives, suspension of this station was recommended by the Field Representatives and later approved by the Accredited Officers. The well and shelter were left on the site so the station can be re-activated on short notice, if necessary. There has been some discussion of completely discontinuing the station, but, because there is the possibility the station may have to be re-activated, the station is in a virtually permanent suspended status. If the station was ever re-activated there would have to be an intensive measurement program to verify or redefine the stage-discharge relation.

6.7.2 Stokke - Buchanan Irrigation Projects Usage

In the early 1960s, Ken Clarke, a WRB hydrometric technician developed a procedure to estimate the usage by the Stokke-Buchanan irrigation projects on Middle Creek. The usage was computed on a separate form titled "Water Use - Stokke-Buchanan Projects" and the total use for the season was included as a minor diversion in the Lodge Creek division. A channel loss function of a constant 3 dam^3/day was used in the calculation. (ref. oral conversation with Ken Clarke).

In 1985 significant expansion was made to the projects to the point where they were "major" rather than "minor" diversions. At the January 28, 1986 meeting of the Field Representatives, it was agreed to include the usage as a major diversion in the Lodge Creek division. The methodology of including the usage was developed in the months following the meeting.

The new procedure required the addition of an entire page to the Lodge Creek natural flow computations and resulted in the revision of several of the old pages. The channel loss function was revised to conform with the function used elsewhere, $L=KD+P(|Q|-KD)$. Following are the K (channel loss constants) and P (variable loss factors) to be used:

Column 27	Middle Creek near Govenlock (11AB108) to Middle Creek above Lodge Creek (11AB008)

Loss Constant K = 1.21 dam^3/day (0.5 cfs/day)

Period	Variable loss factor P
to Mar 29	.01
Mar 30 to Apr 28	.02
Apr 29 to May 29	.03
May 30 to Aug 29	.04
Aug 30 to Sep 28	.03
Sep 29 to Oct 29	.02

Column 31	Middle Creek above Lodge Creek (11AB008) to Lodge Creek below McRae Creek at International Boundary (11AB083)

Loss Constant K = 1.21 dam^3/day (0.5 cfs/day)

Period	Variable loss factor P
to Mar 30	.01
Mar 31 to Apr 29	.02
Apr 30 to May 30	.03
May 31 to Aug 30	.04
Aug 31 to Sep 29	.03
Sep 30 to Oct 30	.02

6.7.3 Squaw Coulee near Willow Creek - 11AB103

This station is used to determine the return flow from the Spangler Ditch irrigation area. If rain occurs during irrigation, natural local inflows must be estimated and separated from return flow.

6.8 REFERENCES

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Yee, B. *Development of Alternative Method of Estimating Minor Diversions*, Water Resources Branch, Regina, Saskatchewan, 1991.

6.9 OTHER INFORMATION SOURCES

The following WRB, Regina files contain a myriad of information relevant to the division of water on the eastern tributaries.

5900/3-3-1	Eastern Tributaries of Milk River Apportionment
5900/3-4	St. Mary-Milk River (includes minutes of annual conferences, items related to the annual report to the IJC, and items related to the Procedures Manual).
5900/3-7-3	Apportionment of Alberta-Saskatchewan Streams
1165-36/BLFB	Battle-Lodge-Frenchman Basins Study Co-ordinating Committee

Basin Files 11A, 11AB, and 11AC.

APPENDIX A

LISTS OF STATIONS

INTERNATIONAL GAUGING STATIONS OPERATED JOINTLY BY THE UNITED STATES AND CANADA
ST. MARY AND MILK RIVER DRAINAGE BASINS

WRB Station Number	USGS Station Number	Station Name
ST. MARY RIVER BASIN		
05AE027	05020500	St. Mary River at International Boundary
05AE029	05018500	St. Mary Canal at St. Mary Crossing near Babb, Montana
05AE033	05016000	Swiftcurrent Creek at Sherburne, Montana
05AE036	05015500	Lake Sherburne at Sherburne, Montana
MILK RIVER BASIN		
11AA001	06134000	North Milk River near International Boundary
11AA005	06134500	Milk River at Milk River
11AA025	06133000	Milk River at Western Crossing of International Boundary
11AA031	06135000	Milk River at Eastern Crossing of International Boundary
11AA032	06133500	North Fork Milk River above St. Mary Canal near Browning, Montana.
11AA033	06132200	South Fork Milk River near Babb, Montana
11AA038	06134700	Verdigris Coulee near the Mouth
LODGE CREEK TRIBUTARY BASIN		
11AB008	06144450	Middle Creek above Lodge Creek
11AB001	06144395	Middle Creek below Middle Creek Reservoir
11AB108	06144440	Middle Creek near Govenlock
11AB009	06144350	Middle Creek near Saskatchewan Boundary
11AB060	06144270	Spangler Ditch near Govenlock
11AB080	06144360	Middle Creek Reservoir
11AB083	06145500	Lodge Creek below McRae Creek at International Boundary
11AB089	06144260	Altawan Reservoir near Govenlock
BATTLE CREEK TRIBUTARY BASIN		
11AB018	06149400	Nashlyn Canal near Consul
11AB027	06149500	Battle Creek at International Boundary
11AB044	06149300	McKinnon Ditch near Consul
11AB058	06149200	Richardson Ditch near Consul
11AB075	06151000	Lyons Creek at International Boundary
11AB077	06149000	Cypress Lake West Outflow Canal
11AB078	06148500	Cypress Lake West Inflow Canal
11AB084	06149100	Vidora Ditch near Consul

WRB Station Number	USGS Station Number	Station Name
11AB085	06148700	Cypress Lake West Inflow Canal Drain
11AB102	06147950	Gaff Ditch near Merryflat
FRENCHMAN RIVER TRIBUTARY BASIN		
11AC001	06159500	Frenchman River below Eastend Reservoir
11AC037	06157000	Cypress Lake
11AC041	06164000	Frenchman River at International Boundary
11AC052	06158500	Eastend Canal near Eastend
11AC054	06162500	Newton Lake Main Canal
11AC055	06159000	Eastend Reservoir
11AC056	06163000	Newton Lake
11AC060	06157500	Cypress Lake East Outflow Canal
11AC062	06163050	Frenchman River below Newton Lake
11AC063	06162000	Huff Lake
11AC064	06156500	Belanger Creek Diversion to Cypress Lake
11AC065	06161500	Huff Lake Gravity Canal
11AC066	06161300	Huff Lake Pumping Canal

GAUGING STATIONS OPERATED INDEPENDENTLY BY EITHER THE UNITED STATES OR CANADA
ST. MARY AND MILK RIVER DRAINAGE BASINS

Station Number	Station Name	Operated by
ST. MARY RIVER BASIN		
05014500	Swiftcurrent Creek at Many Glacier, Montana	U.S.A.
05017500	St. Mary River near Babb, Montana	U.S.A.
MILK RIVER BASIN		
11AA028	Bear Creek near International Boundary	Canada
11AA029	Miners Coulee near International Boundary	Canada
11AA040	Breed Creek near International Boundary	Canada
LODGE CREEK TRIBUTARY BASIN		
11AB082	Lodge Creek at Alberta Boundary	Canada
11AB091	Michel Reservoir near Elkwater	Canada
11AB092	Greasewood Reservoir near Elkwater	Canada
11AB094	Bare Creek Reservoir near Elkwater	Canada
11AB097	Cressday Reservoir near Cressday	Canada
11AB098	Jaydot Reservoir near Jaydot	Canada
11AB099	Mitchell Reservoir near Elkwater	Canada
11AB103	Squaw Coulee near Willow Creek	Canada
11AB104	Massy Reservoir near Elkwater	Canada
11AB114	Middle Creek Reservoir Bedford Outlet	Canada
11AB115	Middle Creek Reservoir Flood Spillway	Canada
BATTLE CREEK TRIBUTARY BASIN		
11AB020	Shepherd Ditch near Consul	Canada
11AB090	Reesor Reservoir near Elkwater	Canada
11AB095	Adams Lake	Canada
11AB096	Battle Creek near Consul	Canada
11AB101	Battle Creek below Nashlyn Project	Canada
11AB117	Battle Creek at Alberta Boundary	Canada
11AB118	Battle Creek below Wilson's Weir	Canada
FRENCHMAN RIVER TRIBUTARY BASIN		
11AC023	Frenchman River at 50-Mile	Canada
11AC025	Denniel Creek near Val Marie	Canada
11AC051	Frenchman River below Val Marie	Canada
11AC068	Val Marie Pump No. 1	Canada
11AC073	Denniel Creek East Tributary	Canada
ROCK CREEK TRIBUTARY BASIN		
06169500	Rock Creek below Horse Creek near International Boundary	U.S.A.

APPENDIX B

LETTER OF INTENT
ST. MARY AND MILK RIVERS STREAMFLOW TRANSFER

LETTER OF INTENT

To better utilize the waters of the St. Mary and Milk Rivers, to provide beneficial use to each country, the signatories to this letter agree to the following procedures for a St. Mary - Milk River Streamflow Transfer. In signing this letter, the parties recognize this agreement is within the 1921 Order of the International Joint Commission. Additionally, the parties recognize this annex will form part of the St. Mary - Milk River Procedural Manual.

R. A. Halliday
Accredited Officer of
Her Majesty

Philip Cohen
Accredited Officer of the
United States

Whereas the United States finds it beneficial to use more than its share of the St. Mary River in the March-May period each year to supply water to U.S. Milk River irrigators;

And whereas, Canada finds it beneficial to use more than its share of the Milk River in the July-September period each year to supply water to Canadian Milk River irrigators;

And whereas, the Boundary Waters Treaty of 1909 and the International Joint Commission Order of 1921 authorizes the Reclamation and Irrigation Officers of the United States and Canada to make the greatest beneficial use of the waters of the St. Mary and Milk Rivers;

It is therefore ordered and directed by said Irrigation and Reclamation Officers that the United States be allowed to accumulate a deficit on the St. Mary River of up to 2,000 cfs-days (4,900 dam^3) between March 1 and May 31 of each year, and that Canada be allowed to accumulate a similar deficit on the Milk River between July 1 and September 31 of each year. Outstanding deficits as of October 1 will be equalized by October 31 of each year under administration by the Field Representatives of the Accredited Officers.

Termination of this procedure will be allowed upon request by either the United States or Canada notifying the other party in writing two months prior to the commencement of the irrigation season (April 1st as specified by the 1921 Order).

APPENDIX C

HANSON EQUATION

March 3, 1849

United States Department of the Interior

TAKE PRIDE IN AMERICA

GEOLOGICAL SURVEY
Water Resources Division
Federal Building, Room 428
301 South Park Avenue, Drawer 10076
Helena, Montana 59626-0076

September 1, 1988

Nick Chapin
Water Survey of Canada
Inland Waters Directorate
Environment Canada
Postal Station "M"
Bag 2909
Calgary, Alberta T2P 2M7

Dear Nick:

So you want to know what the "Hanson equation" is, aye? Well, it is simply an equation that estimates the increase in evapotranspiration in the Milk River due to St. Mary Canal water by using only the Canal flow (North Milk River minus North Fork Milk River) and the four day average evaporation at Fort Assiniboine near Havre. Channel widths, east-west mean flow, and east-west mean evaporation are not used in the computations. We are using this equation in the provisional Milk River Natural Flow computations because the approach is simple and the data is readily available.

I began wondering about a more simple approach to "increment of evaporation" several years ago, and finally put pen to paper. I went to the 1976-78 IJC reports, and pulled out daily mean evaporation, daily Canal flow, the loss per inch of evaporation, and the incremental loss of canal water. I plotted the canal flow vs the loss per inch of evaporation. See attachments for data points and curve.

The dry year, 1977, plotted nicely in two straight lines. All fourteen days of 1977 data using the "Hanson equation" gave incremental evaporation losses within 3cfs of the Report values. I was amazed, but not surprised. The difference in reported values for 1976 and 1978 varied from the "equation" values by as much as 14 cfs, but always when there was abundant natural flow and computations were not critical. Anytime the natural flow dropped below 100 cfs, the two methods varied by no more than 6 cfs, at least on the days I plotted.

With daily natural flow values varying as much as they do anyway, I decided a measly 6 cfs was rather small in the overall scheme of things. Consumptive use estimates are probably no closer than ±10 cfs. So, undaunted, we have decided to use the "Hanson equation" in provisional Milk River Natural Flow computations. The next step will be to compare those figures with those using Morton's model.

If you are actually interested in the math, the equations are:

$L = .4CF$ when $CF < 200$ cfs
$L = .095CF + 61$ when $CF > 200$ cfs
where:
L = Evaporation loss per inch of evaporation
CF = Canal Flow (North Milk River minus flow at North Fork Milk River)

These lines are best fit to a dry year when computations are most critical. Call if you have questions.

Sincerely,

Dave

David B. Hanson
Chief, International Section

Enclosures

APPENDIX D

COMPUTATIONS AND EXCHANGE OF DATA FOR STATIONS IN THE EASTERN TRIBUTARIES OF THE MILK RIVER

Following are some guidelines regarding the priorities of hydrometric computations, and what data must be exchanged between WRB and the USGS and when it must be done.

COPYING DISCHARGE MEASUREMENT NOTES

The following procedures were outlined in a memo from Gerry Morton, Regional Chief, WRB, Calgary dated 1983-04-18 and have been accepted by the Field Representatives.

1. Checked original notes for any flow measurements at, or visit made to, an international gauging station will be forwarded to the District office responsible for the station, within two weeks of obtaining the measurement.

2. When the original notes are to be sent to a District office in the other country, a copy of the cover sheet of the notes will be retained in the District office of the field officer who made the measurement.

3. A copy of the front sheet for checked measurements will be forwarded to the District office not responsible for the station, within two weeks of obtaining the measurement.

4. Original discharge measurements are to be retained by both countries indefinitely.

5. If either country institutes a policy of microfilming measurements and destroying originals, then all discharge measurements are to be returned to the country which made the measurement.

STATIONS ALONG THE INTERNATIONAL BOUNDARY OPERATED BY THE USGS

All original data (charts, measurement and level notes) should be sent to USGS as soon as practicable after data has been retrieved from the field.

USGS will send WRB prints of their computation forms for quality checking.

11AE009	Rock Creek below Horse Creek - nonapportionment - digital - Ft. Peck
11AC041	Frenchman River
11AB075	Lyons Creek - non-apportionment
11AB027	Battle Creek
11AB083	Lodge Creek below McRae Creek

Note: If a chart is pulled by WRB, WRB computes it manually, makes a print for themselves and sends the original to Helena.

If USGS pulls the chart they will:

(a) compute it manually and send WRB a print for checking, or

(b) leave chart in Shaunavon or send to Regina for provisional computation. WRB will retain a print and send original to Helena.

The final annual listings in SI units for the Frenchman River, Lyons Creek, Battle Creek and Lodge Creek stations are generated by WRB for signing purposes and inclusion in the report to the IJC. These listings are generated from the USGS listings and the MANUAL program.

INTERNATIONAL CATEGORY FLOW STATIONS OPERATED BY WRB

Prints of all forms (charts, meter and level notes, gauge corrections, discharge measurement summaries, backwater computations, gauge history, stage-discharge curve and table, 4 month/page listing, hydrograph on grid paper, and any special forms used in the computations) are sent to Helena for quality checking. Round-trip memos should be attached for confirmation purposes. When data has been approved by memo, the 12 month/page listing and daily discharge output is obtained. The annual listing is signed "approved" by the District/Regional Chiefs at the annual St. Mary-Milk River Records Conference. Daily discharge output is duplicated and put on tape for the USGS.

Note: final annual listings are to be letter quality prints (in duplicate)

INTERNATIONAL CATEGORY RESERVOIR STATIONS OPERATED BY WRB

Prints of all forms (charts, level notes, 8 hour and annual listing, evaporation data, 10 day evaporation and storage sheets), are sent to Helena for quality checking. When data has been approved by memo, output of daily elevations is obtained for Ottawa.

SEMI-INTERNATIONAL FLOW STATIONS OPERATED BY WRB

These are stations used in the natural flow computations but are not important enough to warrant "International" classification. The stations are computed as normal WRB stations but, as they do not go to Helena for checking, the stations are second in priority for computing. Helena gets a copy of the final annual listing.

SEMI-INTERNATIONAL WATER LEVEL STATIONS OPERATED BY WRB

These consist of 8 small reservoirs in the upper Battle and upper Lodge Creek basins that are used in the natural flow computations but do not warrant "International" classification. For the manual stations: Greasewood, Cressday, and Mitchell reservoirs, and Reesor and Adams lakes, the final listing and water level output is obtained from a "dummy" deck with the gauge heights on updating correction records as most of the record is estimated from a graph of a few observed -readings. Helena gets a copy of the graph and 10-day evaporation and storage sheet.

PRIORITIES

The deadline for submission of the St. Mary-Milk River Annual Report to the IJC is mid-March. To meet this deadline natural flow computations must be completed by mid-January, and accordingly, all hydrometric computations for stations used to compute the natural flow must be completed prior to mid-January.

Priorities have been made in the order of computation. International stations used in the natural flow computations must be computed first and sent to Helena for quality checking. Non-international stations used in the natural flow computations are computed second. International non-division stations are computed third.

The postal service slows down considerably just before Christmas, so all International stations should be mailed before December 15. After December 15 all correspondence and records are sent by courier or faxed.

Many International stations are irrigation canals and most irrigation ends by August 15. Final computations for the irrigation period can begin in August or early September on Spangler Ditch, Gaff Ditch, Vidora Ditch, Richardson Ditch, McKinnon Ditch, Nashlyn Canal, Eastend Canal, Huff Lake Gravity Canal, Huff Lake Pumping Canal, and Newton Lake Main Canal. Similarly final computations for the irrigation period for stations required for return flow computations (Battle Creek Below Wilson's Weir, Battle Creek near Consul, and Battle Creek below Nashlyn Project) can also begin in August or early September.

If a new or extended stage-discharge curve is developed for a station, that curve should be sent to Helena for checking as soon as possible.

GEOGRAPHICAL LIST OF STATIONS AND ORDER OF PRIORITY FOR COMPUTATION

NOTE: All stations computed by WRB unless otherwise indicated.

LODGE CREEK BASIN

		PRIORITY
11AB091	Michel Reservoir near Elkwater	2
11AB104	Massy Reservoir near Elkwater	2
11AB092	Greasewood Reservoir near Elkwater	2
11AB094	Bare Creek Reservoir near Elkwater	2
11AB097	Cressday Reservoir near Cressday	2
11AB098	Jaydot Reseervoir near Jaydot	2
11AB082	Lodge Creek near Alberta Boundary	3
11AB089	Altawan Reservoir near Govenlock	1
11AB060	Spangler Ditch near Govenlock	1
11AB103	Squaw Coulee near Willow Creek	2
11AB083	Lodge Creek below McRae Creek at International Boundary (USGS)	1

Middle Creek Sub-basin

11AB099	Mitchell Reservoir	2
11AB009	Middle Creek near Saskatchewan Boundary	1
11AB080	Middle Creek Reservoir (required for contents only)	2
11AB114	Middle Creek Reservoir Bedford Outlet	2
11AB115	Middle Creek Reservoir Flood Spillway	2
11AB001	Middle Creek below Middle Creek Reservoir	1
11AB108	Middle Creek near Govenlock	1
11AB008	Middle Creek above Lodge Creek	1

BATTLE CREEK BASIN

11AB090	Reesor Reservoir near Elkwater	2
11AB117	Battle Creek at Alberta Boundary	3
11AB095	Adams Lake	2
11AB102	Gaff Ditch near Merryflat	1
11AB020	Shepherd Ditch near Consul	2
11AB078	Cypress Lake West Inflow Canal	1
11AB085	Cypress Lake West Inflow Canal Drain	1
11AB118	Battle Creek below Wilson's Weir	2
11AB077	Cypress Lake West Outflow Canal	1
11AB084	Vidora Ditch near Consul	1
11AB058	Richardson Ditch near Consul	1

11AB044	McKinnon Ditch near Consul	1
11AB096	Battle Creek near Consul	2
11AB018	Nashlyn Canal near Consul	1
11AB101	Battle Creek below Nashlyn Project	2
11AB027	Battle Creek at International Boundary (USGS)	1
11AB075	Lyons Creek at International Boundary (USGS)	1

FRENCHMAN RIVER BASIN

11AC064	Belanger Creek Diversion to Cypress Lake	1
11AC037	Cypress Lake (required for contents only)	2
11AC060	Cypress Lake East Outflow Canal	1
11AC055	Eastend Reservoir	1
11AC052	Eastend Canal	1
11AC001	Frenchman River below Eastend Reservoir	2
11AC063	Huff Lake	1
11AC066	Huff Lake Pumping Canal	1
11AC065	Huff Lake Gravity Canal	1
11AC068	Val Marie Pump No. 1	2
11AC056	Newton Lake	1
11AC054	Newton Lake Main Canal	1
11AC062	Frenchman River below Newton Lake	2
11AC041	Frenchman River at International Boundary (USGS)	1

Other Basins

11AE009	Rock Creek below Horse Creek (USGS)	3
11AF005	Beaver Creek at International Boundary	3
11AE003	East Poplar River at International Boundary (USGS)	3
11AE008	Poplar River at International Boundary (USGS)	3

NOTE: *The above four stations are not directly related to the apportionment of the Eastern Tributaries of the Milk River; however, efforts are made to complete the hydrometric computations for the January meeting of the Field Representatives to facilitate signing of the records.*

The following is a check list for the various items required for the natural flow computations, report to the IJC, and requirements of the USGS.

Eastern Tributaries of the Milk River Annual Checklist

		Location	Computed by	Final Listing Req'd for IJC Report	Done	Final Listing Req'd for USGS	Done	Signed two copies	Done	Daily Q Output Req'd by U.S.	Done	Natural Flow Program Requirements and comments	Done
Battle Creek Basin													
International													
11AB018	Nashlyn Canal near Consul	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB027	Battle Creek at International Boundary	Canada	U.S.	Y		Y		Y		Y		Daily Q, WRB makes SI signing copy	
11AB044	McKinnon Ditch near Consul	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB058	Richardson Ditch near Consul	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB075	Lyons Creek at International Boundary	Canada	U.S.	Y		Y		Y		Y		WRB makes SI signing copy	
11AB077	Cypress Lake West Outflow Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB078	Cypress Lake West Inflow Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB084	Vidora Ditch near Consul	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB085	Cypress Lake West Inflow Canal Drain	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB102	Gaff Ditch near Merryflat	Canada	Canada	Y		Y		Y		Y		Daily Q	
Non-International													
11AB020	Shepherd Ditch near Consul	Canada	Canada	N		N		N		N		Minor div (10 day vol)	
11AB090	Reesor Reservoir	Canada	Canada	N		N		N		N		Period-end & mean elev	
11AB095	Adams Lake	Canada	Canada	N		N		N		N		Period-end & mean elev	
11AB096	Battle Creek near Consul	Canada	Canada	N		N		N		N		Return flow computations	
11AB101	Battle Creek below Nashlyn Project	Canada	Canada	N		N		N		N		Return flow computations	
11AB117	Battle Creek at Alberta Boundary	Canada	Canada	N		N		N		N			
11AB118	Battle Creek below Wilson's Weir	Canada	Canada	N		N		N		N		Return flow computations	
Lodge Creek Basin													
International													
11AB001	Middle Creek below Middle Creek Reservoir	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB008	Middle Creek above Lodge Creek	Canada	Canada	Y		Y		Y		Y		10 day volumes	
11AB009	Middle Creek near Saskatchewan Boundary	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB060	Spengler Ditch near Govenlock	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AB080	Middle Creek Reservoir	Canada	Canada	Y		Y		Y		N			
11AB083	Lodge Creek below McRae Creek at International Boundary	Canada	U.S.	Y		Y		Y		Y		Daily Q, WRB makes SI signing copy	
11AB089	Altawan Reservoir near Govenlock	Canada	Canada	N		Y		Y		N		Period-end midnite elev. & card output	
11AB108	Middle Creek near Govenlock	Canada	Canada	Y		Y		Y		Y		10 day volumes	
Non-International													
11AB082	Lodge Creek at Alberta Boundary	Canada	Canada	N		N		N		N			
11AB091	Michel Reservoir near Elkwater	Canada	Canada	N		N		N		N		Period-end midnite elev. & card output	
11AB092	Greasewood Reservoir near Elkwater	Canada	Canada	N		N		N		N		Period-end & mean elev.	
11AB094	Bare Creek Reservoir near Elkwater	Canada	Canada	N		N		N		N		Period-end midnite elev. & card output	
11AB097	Cressday Reservoir near Cressday	Canada	Canada	N		N		N		N		Period-end & mean elev.	
11AB098	Jaydot Reservoir near Jaydot	Canada	Canada	N		N		N		N		Period-end midnite elev. & card output	
11AB099	Mitchell Reservoir near Elkwater	Canada	Canada	N		N		N		N		Period-end & mean elev.	
11AB103	Squaw Coulee near Willow Creek	Canada	Canada	Y		N		N		N		Daily Q	
11AB104	Massy Reservoir near Elkwater	Canada	Canada	N		N		N		N		Period-end midnite elev. & card output	
11AB114	Middle Creek Reservoir Bedford Outlet	Canada	Canada	Y		N		N		N		Daily Q	
11AB115	Middle Creek Reservoir Flood Spillway	Canada	Canada	Y		N		N		N		Daily Q	

		Location	Computed by	Final Listing Req'd for IJC Report	Done	Final Listing Req'd for USGS	Done	Signed	Done	Daily Q Req'd by U.S.	Done	Natural Flow Program Requirements and comments	Done
Frenchman River Basin													
International													
11AC001	Frenchman River below Eastend Reservoir	Canada	Canada	Y		Y		Y		Y			
11AC037	Cypress Lake	Canada	Canada	N		Y		Y		N			
11AC041	Frenchman River at International Boundary	Canada	U.S.	Y		Y		Y		Y		Daily Q, WRB makes SI signing copy	
11AC052	Eastend Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AC054	Newton Lake Main Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AC055	Eastend Reservoir	Canada	Canada	N		Y		Y		N		Period-end midnite elev. & card output	
11AC056	Newton Lake	Canada	Canada	N		Y		Y		N		Period-end midnite elev. & card output	
11AC060	Cypress Lake East Outflow Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AC062	Frenchman River below Newton Lake	Canada	Canada	Y		Y		Y		Y			
11AC063	Huff Lake	Canada	Canada	N		Y		Y		N		Period-end midnite elev. & card output	
11AC064	Belanger Creek Diversion to Cypress Lake	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AC065	Huff Lake Gravity Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
11AC066	Huff Lake Pumping Canal	Canada	Canada	Y		Y		Y		Y		Daily Q	
Non-International													
11AC023	Frenchman River at 50-Mile	Canada	Canada	N		N		N		N		Special study station	
11AC025	Denniel Creek near Val Marie	Canada	Canada	N		N		N		N			
11AC051	Frenchman River below Val Marie	Canada	Canada	N		N		N		N		Special study station	
11AC068	Val Marie Pump No. 1	Canada	Canada	N		N		N		N		Minor div (10 day vol)	
	Val Marie Pump No. 2	Canada	Canada	N		N		N		N		Minor div	
11AC075	Denniel Creek East Tributary near Val Marie	Canada	Canada	N		N		N		N		Special study station	
Evaporation Stations													
11EV089	Altawan Evaporation			Y		N		N		N		Daily Q	
11EV063	Val Marie Evaporation			Y		N		N		N		Daily Q	
Poplar River Basin													
11AE008	Poplar River at International Boundary	U.S.	U.S.	N		N		Y		N		U.S. generates signing copy	
11AE003	East Poplar River at International Boundary	Canada	U.S.	N		N		Y		N		U.S. generates signing copy	
11AF005	Beaver Creek at International Boundary	Canada	Canada	N		Y		Y		Y			

NOTES:
Letter quality prints are required for those listings entering the IJC report.

Battle Creek Natural Flow - Period-end and mean elevations for Reesor and Adams must be manually input into the natural flow computer program. Return flows are manually calculated and either 10-day period volumes or a percentage is manually input. Shepherd Ditch is operated as a regular discharge station; ten-day volumes are calculated from the final listing and included as a minor diversion. Minor diversions are then manually input.

Lodge Creek Natural Flow - Period-end midnight elevations for Altawan, Michel, Bare, Jaydot, and Massy reservoirs must be manually input into the natural flow computer program. Period-end and mean elevations for Greasewood, Cressday, and Mitchell reservoirs must be manually input. Middle Creek above Lodge Creek and Middle Creek near Govenlock are required to calculate net depletion of the Stokke-Buchanan projects; ten-day volumes are calculated from the final listings and are then manually input. Minor diversions are manually input.

Frenchman River Natural Flow - Period-end midnight elevations for Eastend Reservoir, Huff and Newton Lakes are manually input into the natural flow computer program. Ten-day volumes are calculated from the final listing for Val Marie Pump No. 1 and included with the minor diversions. A volume of usage for Val Marie Pump No. 2 iscalculated from power meter readings and pump ratings; the volume is included with the minor diversions. Minor diversions are manually input.

Evaporation - daily evaporation values (in meters) are entered as discharges using Updating Corrections in the @WSC procedures. Daily discharge output is produced as in a normal discharge station.

Minor Diversions - Contact persons for minor diversion data are:

Hamid Rahim, Water Allocation Manager, Water Rights Branch, Water Resources Administration Division,
Alberta Environment, 2nd Floor, Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta, T5K 2J6
ph: (403)427-6111

Pat Graham, Customer Services, Southwest Region, Operations Division, Sask Water, 350 Cheadle Street West,
Swift Current, Saskatchewan, S9H 4G3
ph: (306)778-8267

Major Reservoirs - month-end contents for Cypress Lake, Middle Creek Reservoir, Altawan Reservoir, Eastend Reservoir, Huff Lake and Newton Lake are required for Table 16, Appendix A in the IJC Report.

APPENDIX E

TABULAR FORMS FOR COMPUTING LODGE, BATTLE, AND FRENCHMAN DIVISIONS

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		1	2	3	4	5	6	7	8	9
Period	Period Upper Lodge Area	Michel Reservoir Depletion	Greasewood Reservoir Depletion	Massy Reservoir Depletion	Total Depletion Upper Lodge Reservoirs	Channel Loss to International Boundary	Net Depletion Upper Lodge	Bare Creek Reservoir Depletion	Channel Loss to International Boundary	Net Depletion Bare Creek
		Observed	Observed	Observed	1 + 2 + 3	7.34 dam3/day +% of remainder	4 – 5	Observed	7.34 dam3/day +% of remainder	7 – 8
1	Feb 25–Mar 6					6			6	
2	Mar 7 – 16					6			6	
3	Mar 17 – 27					6			6	
4	Mar 28–Apr 6					9			9	
5	Apr 7 – 16					9			9	
6	Apr 17 – 26					9			9	
7	Apr 27–May 6					15			15	
8	May 7 – 16					15			15	
9	May 17 – 27					15			15	
10	May 28–Jun 6					24			24	
11	Jun 7 – 16					24			24	
12	Jun 17 – 26					24			24	
13	Jun 27–Jul 6					24			24	
14	Jul 7 – 16					24			24	
15	Jul 17 – 27					24			24	
16	Jul 28–Aug 6					24			24	
17	Aug 7 – 16					24			24	
18	Aug 17 – 27					24			24	
19	Aug 28–Sep 6					15			15	
20	Sep 7 – 16					15			15	
21	Sep 17 – 26					15			15	
22	Sep 27–Oct 6					9			9	
23	Oct 7 – 16					9			9	
24	Oct 17 – 27					9			9	

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		10	11	12	13	14	15		16	17	18
Period	Period Cressday and Mitchell Reservoir Areas	Cressday Reservoir Depletion	Channel Loss to International Boundary	Net Depletion Cressday	Mitchell Reservoir Depletion	Channel Loss to International Boundary	Net Depletion Mitchell	Period Jaydot Reservoir Area	Jaydot Reservoir Depletion	Channel Loss to International Boundary	Net Depletion Jaydot
		Observed	4.92 dam3/day +% of remainder	10 – 11	Observed	4.92 dam3/day +% of remainder	13 – 14		Observed	2.42 dam3/day +% of remainder	16 – 17
1	Feb 26–Mar 7		4			4		Feb 27–Mar 8		2	
2	Mar 8 – 17		4			4		Mar 9 – 18		2	
3	Mar 18 – 28		4			4		Mar 19 – 29		2	
4	Mar 29–Apr 7		6			6		Mar 30–Apr 8		3	
5	Apr 8 – 17		6			6		Apr 9 – 18		3	
6	Apr 18 – 27		6			6		Apr 19 – 28		3	
7	Apr 28–May 7		10			10		Apr 29–May 8		5	
8	May 8 – 17		10			10		May 9 – 18		5	
9	May 18 – 28		10			10		May 19 – 29		5	
10	May 29–Jun 7		16			16		May 30–Jun 8		8	
11	Jun 8 – 17		16			16		Jun 9 – 18		8	
12	Jun 18 – 27		16			16		Jun 19 – 28		8	
13	Jun 28–Jul 7		16			16		Jun 29–Jul 8		8	
14	Jul 8 – 17		16			16		Jul 9 – 18		8	
15	Jul 18 – 28		16			16		Jul 19 – 29		8	
16	Jul 29–Aug 7		16			16		Jul 30–Aug 8		8	
17	Aug 8 – 17		16			16		Aug 9 – 18		8	
18	Aug 18 – 28		16			16		Aug 19 – 29		8	
19	Aug 29–Sep 7		10			10		Aug 30–Sep 8		5	
20	Sep 8 – 17		10			10		Sep 9 – 18		5	
21	Sep 18 – 27		10			10		Sep 19 – 28		5	
22	Sep 28–Oct 7		6			6		Sep 29–Oct 8		3	
23	Oct 8 – 17		6			6		Oct 9 – 18		3	
24	Oct 18 – 28		6			6		Oct 19 – 29		3	

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19___

All quantities in cubic decametres

		19	20	21	22	23	24	25
Period	Period Middle Creek Reservoir Area	Middle Creek near Sask. Boundary (Reservoir Inflow)	Bedford Outlet	Flood Spillway	Middle Creek below Middle Creek Reservoir (Reservoir outflow & Irrigation return flow)	Gross Depletion	Channel Loss to International Boundary	Net Depletion Middle Creek
		Observed	Observed	Observed	Observed	19−20−21−22	4.92 dam3/day +% of remainder	23 − 24
1	Feb 26–Mar 7						4	
2	Mar 8 – 17						4	
3	Mar 18 – 28						4	
4	Mar 29–Apr 7						6	
5	Apr 8 – 17						6	
6	Apr 18 – 27						6	
7	Apr 28–May 7						10	
8	May 8 – 17						10	
9	May 18 – 28						10	
10	May 29–Jun 7						16	
11	Jun 8 – 17						16	
12	Jun 18 – 27						16	
13	Jun 28–Jul 7						16	
14	Jul 8 – 17						16	
15	Jul 18 – 28						16	
16	Jul 29–Aug 7						16	
17	Aug 8 – 17						16	
18	Aug 18 – 28						16	
19	Aug 29–Sep 7						10	
20	Sep 8 – 17						10	
21	Sep 18 – 27						10	
22	Sep 28–Oct 7						6	
23	Oct 8 – 17						6	
24	Oct 18 – 28						6	

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		26	27			28	29	30	31		32
Period	Period Middle Creek Near Govenlock	Middle Creek Near Govenlock	Channel Loss To Middle Creek Above Lodge Creek		Period To Middle Creek Above Lodge Creek	Apparent Flow At Middle Creek Above Lodge Creek	Measured Flow At Middle Creek Above Lodge Creek	Water Use Stokke – Buchanan Projects	Channel Loss to International Boundary		Net Depletion Stokke – Buchanan
		Observed	1.21 dam3/day +% of remainder			26 – 27	Observed	28 – 29	1.21 dam3/day +% of remainder		30 – 31
1	Feb 27–Mar 8		1		Feb 28–Mar 9				1		
2	Mar 9 – 18		1		Mar 10 – 19				1		
3	Mar 19 – 29		1		Mar 20 – 30				1		
4	Mar 30–Apr 8		2		Mar 31–Apr 9				2		
5	Apr 9 – 18		2		Apr 10 – 19				2		
6	Apr 19 – 28		2		Apr 20 – 29				2		
7	Apr 29–May 8		3		Apr 30–May 9				3		
8	May 9 – 18		3		May 10 – 19				3		
9	May 19 – 29		3		May 20 – 30				3		
10	May 30–Jun 8		4		May 31–Jun 9				4		
11	Jun 9 – 18		4		Jun 10 – 19				4		
12	Jun 19 – 28		4		Jun 20 – 29				4		
13	Jun 29–Jul 8		4		Jun 30–Jul 9				4		
14	Jul 9 – 18		4		Jul 10 – 19				4		
15	Jul 19 – 29		4		Jul 20 – 30				4		
16	Jul 30–Aug 8		4		Jul 31–Aug 9				4		
17	Aug 9 – 18		4		Aug 10 – 19				4		
18	Aug 19 – 29		4		Aug 20 – 30				4		
19	Aug 30–Sep 8		3		Aug 31–Sep 9				3		
20	Sep 9 – 18		3		Sep 10 – 19				3		
21	Sep 19 – 28		3		Sep 20 – 29				3		
22	Sep 29–Oct 8		2		Sep 30–Oct 9				2		
23	Oct 9 – 18		2		Oct 10 – 19				2		
24	Oct 19 – 29		2		Oct 20 – 30				2		

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		33	34	35	36	37	38	39
Period	Period Altawan Reservoir Area	Altawan Reservoir Depletion	Spangler Ditch	Return Flow From Spangler Ditch –Squaw Coulee	Return Flow From Bedford Outlet –Walburger Coulee	Gross Depletion	Channel Loss to International Boundary	Net Depletion Altawan
		Observed	Observed	Observed	Observed	33+34–35–36	2.42 dam3/day +% of remainder	37 – 38
1	Feb 27–Mar 8						2	
2	Mar 9 – 18						2	
3	Mar 19 – 29						2	
4	Mar 30–Apr 8						3	
5	Apr 9 – 18						3	
6	Apr 19 – 28						3	
7	Apr 29–May 8						5	
8	May 9 – 18						5	
9	May 19 – 29						5	
10	May 30–Jun 8						8	
11	Jun 9 – 18						8	
12	Jun 19 – 28						8	
13	Jun 29–Jul 8						8	
14	Jul 9 – 18						8	
15	Jul 19 – 29						8	
16	Jul 30–Aug 8						8	
17	Aug 9 – 18						8	
18	Aug 19 – 29						8	
19	Aug 30–Sep 8						5	
20	Sep 9 – 18						5	
21	Sep 19 – 28						5	
22	Sep 29–Oct 8						3	
23	Oct 9 – 18						3	
24	Oct 19 – 29						3	

NATURAL FLOW OF LODGE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19___

All quantities in cubic decametres

		40	41	42	43	44	45	46
Period	Period At International Boundary	Net Depletion In Canada	Minor Irrigation Diversions	Lodge Creek at International Boundary	Natural Flow Of Lodge Creek	U.S.A. Share Of Natural Flow	Excess Flow To U.S.A.	Deficit(−) To Date
		6+9+12+15+18 +25+32+39	Estimated	Observed	40+41+42	50% of 43	42 − 44	Sum of 45
1	Mar 1 – 10							
2	Mar 11 – 20							
3	Mar 21 – 31							
4	Apr 1 – 10							
5	Apr 11 – 20							
6	Apr 21 – 30							
7	May 1 – 10							
8	May 11 – 20							
9	May 21 – 31							
10	Jun 1 – 10							
11	Jun 11 – 20							
12	Jun 21 – 30							
13	Jul 1 – 10							
14	Jul 11 – 20							
15	Jul 21 – 31							
16	Aug 1 – 10							
17	Aug 11 – 20							
18	Aug 21 – 31							
19	Sep 1 – 10							
20	Sep 11 – 20							
21	Sep 21 – 30							
22	Oct 1 – 10							
23	Oct 11 – 20							
	Oct 21 – 31							

NATURAL FLOW OF BATTLE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		1	2	3		4	5	6	7	8
Period	Period Reesor Lake Area	Reesor Lake Depletion	Channel Loss To International Boundary	Net Depletion Reesor Lake Area	Period Gaff Ditch Area	Gaff Ditch	Return Flow	Gross Depletion Gaff Ditch	Channel Loss To International Boundary	Net Depletion Gaff Ditch
		Observed	14.7 dam3/day	1 – 2		Measured	35% of 4	4 – 5	9.76 dam3/day	6 – 7
1	Feb 23–Mar 8				Feb 25–Mar 10					
2	Mar 9 – 19				Mar 11 – 21					
3	Mar 20 – 29				Mar 22 – 31					
4	Mar 30–Apr 8				Apr 1 – 10					
5	Apr 9 – 18				Apr 11 – 20					
6	Apr 19 – 28				Apr 21 – 30					
7	Apr 29–May 8				May 1 – 10					
8	May 9 – 19				May 11 – 21					
9	May 20 – 29				May 22 – 31					
10	May 30–Jun 8				Jun 1 – 10					
11	Jun 9 – 18				Jun 11 – 20					
12	Jun 19 – 28				Jun 21 – 30					
13	Jun 29–Jul 8				Jul 1 – 10					
14	Jul 9 – 19				Jul 11 – 21					
15	Jul 20 – 29				Jul 22 – 31					
16	Jul 30–Aug 8				Aug 1 – 10					
17	Aug 9 – 19				Aug 11 – 21					
18	Aug 20 – 29				Aug 22 – 31					
19	Aug 30–Sep 8				Sep 1 – 10					
20	Sep 9 – 18				Sep 11 – 20					
21	Sep 19 – 28				Sep 21 – 30					
22	Sep 29–Oct 8				Oct 1 – 10					
23	Oct 9 – 19				Oct 11 – 21					
24	Oct 20 – 25				Oct 22 – 27					

NATURAL FLOW OF BATTLE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		9	10	11	12	13	14	15	16	17	18
Period	Period Cypress Lake Area	West Inflow Canal	West Outflow Canal	West Inflow Canal Drain	Total Release From Cypress Lake	Net Diversion To Cypress Lake	Vidora Ditch	Return Flow	Gross Depletion Cypress Lake	Channel Loss to International Boundary	Net Depletion Cypress Lake
		Measured	Measured	Measured	10 + 11	9 – 12	Measured	25 % of 14 (4 day lag)	13+14–15	7.34 dam3/day	16 – 17
1	Feb 26–Mar 11										
2	Mar 12 – 22										
3	Mar 23–Apr 1										
4	Apr 2 – 11										
5	Apr 12 – 21										
6	Apr 22–May 1										
7	May 2 – 11										
8	May 12 – 22										
9	May 23–Jun 1										
10	Jun 2 – 11										
11	Jun 12 – 21										
12	Jun 22–Jul 1										
13	Jul 2 – 11										
14	Jul 12 – 22										
15	Jul 23–Aug 1										
16	Aug 2 – 11										
17	Aug 12 – 22										
18	Aug 23–Sep 1										
19	Sep 2 – 11										
20	Sep 12 – 21										
21	Sep 22–Oct 1										
22	Oct 2 – 11										
23	Oct 12 – 22										
24	Oct 23 – 28										

NATURAL FLOW OF BATTLE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19___

All quantities in cubic decametres

		19	20	21	22	23	24
Period	Period Consul Area	Richardson Ditch	McKinnon Ditch	Return Flow	Gross Depletion At Consul	Channel Loss To International Boundary	Net Depletion At Consul
		Measured	Measured	25% of 19 & 20 (2 day lag)	19+20−21	4.92 dam3/day	22 − 23
1	Feb 27–Mar 12						
2	Mar 13 – 23						
3	Mar 24–Apr 2						
4	Apr 3 – 12						
5	Apr 13 – 22						
6	Apr 23–May 2						
7	May 3 – 12						
8	May 13 – 23						
9	May 24–Jun 2						
10	Jun 3 – 12						
11	Jun 13 – 22						
12	Jun 23–Jul 2						
13	Jul 3 – 12						
14	Jul 13 – 23						
15	Jul 24–Aug 2						
16	Aug 3 – 12						
17	Aug 13 – 23						
18	Aug 24–Sep 2						
19	Sep 3 – 12						
20	Sep 13 – 22						
21	Sep 23–Oct 2						
22	Oct 3 – 12						
23	Oct 13 – 23						
24	Oct 24 – 29						

NATURAL FLOW OF BATTLE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		25	26	27	28	29
Period	Period Nashlyn Area	Nashlyn Canal	Return Flow	Gross Depletion At Nashlyn	Channel Loss To International Boundary	Net Depletion At Nashlyn
		Measured	25% of 25 (2 day lag)	25 – 26	2.42 dam3/day	27 – 28
1	Feb 28–Mar 13					
2	Mar 14 – 24					
3	Mar 25–Apr 3					
4	Apr 4 – 13					
5	Apr 14 – 23					
6	Apr 24–May 3					
7	May 4 – 13					
8	May 14 – 24					
9	May 25–Jun 3					
10	Jun 4 – 13					
11	Jun 14 – 23					
12	Jun 24–Jul 3					
13	Jul 4 – 13					
14	Jul 14 – 24					
15	Jul 25–Aug 3					
16	Aug 4 – 13					
17	Aug 14 – 24					
18	Aug 25–Sep 3					
19	Sep 4 – 13					
20	Sep 14 – 23					
21	Sep 24–Oct 3					
22	Oct 4 – 13					
23	Oct 14 – 24					
24	Oct 25 – 30					

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NATURAL FLOW OF BATTLE CREEK AT THE INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		30	31	32	33	34	35	36	37
Period	Period At International Boundary	Net Depletion In Canada	Battle Creek At International Boundary	Apparent Natural Flow Of Battle Creek	Adjustment For Minor Diversions & Dom. Use	Natural Flow Of Battle Creek	U.S.A. Share Of Natural Flow	Excess Flow To The U.S.A.	Deficit(−) To Date
		3+8+18+24+29	Measured	30 + 31	Estimated	32 + 33	50% of 34	31 − 35	Sum of 36
1	Mar 1 − 14								
2	Mar 15 − 25								
3	Mar 26−Apr 4								
4	Apr 5 − 14								
5	Apr 15 − 24								
6	Apr 25−May 4								
7	May 5 − 14								
8	May 15 − 25								
9	May 26−Jun 4								
10	Jun 5 − 14								
11	Jun 15 − 24								
12	Jun 25−Jul 4								
13	Jul 5 − 14								
14	Jul 15 − 25								
15	Jul 26−Aug 4								
16	Aug 5 − 14								
17	Aug 15 − 25								
18	Aug 26−Sep 4								
19	Sep 5 − 14								
20	Sep 15 − 24								
21	Sep 25−Oct 4								
22	Oct 5 − 14								
23	Oct 15 − 25								
24	Oct 26 − 31								

NATURAL FLOW OF FRENCHMAN RIVER AT INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		1	2	3	4	5		6	7	8	9	10	11
Period	Period For Cypress Lake Area	Belanger Creek Diversion	Cypress Lake East Outflow Canal	Gross Depletion At Cypress Lake	Channel Loss to International Boundary	Net Depletion At Cypress Lake	Period For Eastend Area	Eastend Reservoir Depletion	Eastend Canal	Return Flow	Gross Depletion At Eastend	Channel Loss to International Boundary	Net Depletion At Eastend
		Measured	Measured	1 – 2	14.7 dam3/day +% of remainder	3 – 4		Observed	Measured	25% of 7	6+7–8	12.3 dam3/day +% of remainder	9–10
1	Feb 20–Mar 1				12		Feb 22–Mar 3					10	
2	Mar 2 – 11				12		Mar 4 – 13					10	
3	Mar 12 – 22				12		Mar 14 – 24					10	
4	Mar 23–Apr 1				12		Mar 25–Apr 3					10	
5	Apr 2 – 11				18		Apr 4 – 13					15	
6	Apr 12 – 21				18		Apr 14 – 23					15	
7	Apr 22–May 1				18		Apr 24–May 3					15	
8	May 2 – 11				30		May 4 – 13					25	
9	May 12 – 22				30		May 14 – 24					25	
10	May 23–Jun 1				30		May 25–Jun 3					25	
11	Jun 2 – 11				48		Jun 4 – 13					40	
12	Jun 12 –21				48		Jun 14 –23					40	
13	Jun 22–Jul 1				48		Jun 24–Jul 3					40	
14	Jul 2 – 11				48		Jul 4 – 13					40	
15	Jul 12 – 22				48		Jul 14 – 24					40	
16	Jul 23–Aug 1				48		Jul 25–Aug 3					40	
17	Aug 2 – 11				48		Aug 4 – 13					40	
18	Aug 12 – 22				48		Aug 14 – 24					40	
19	Aug 23–Sep 1				48		Aug 25–Sep 3					40	
20	Sep 2 – 11				30		Sep 4 – 13					25	
21	Sep 12 – 21				30		Sep 14 – 23					25	
22	Sep 22–Oct 1				30		Sep 24–Oct 3					25	
23	Oct 2 – 11				18		Oct 4 – 13					15	
24	Oct 12 – 22				18		Oct 14 – 24					15	

NATURAL FLOW OF FRENCHMAN RIVER AT INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		12	13	14	15	16	17	18	19	20	21	22
Period	Period For Val Marie Area	Huff Lake Net Depletion	Newton Lake Net Depletion	Total Change in Reservoir Contents	Huff Lake Gravity Canal	Huff Lake Pumping Canal	Newton Lake Main Canal	Total Canal Diversion	Return Flow	Gross Depletion At Val Marie	Channel Loss to International Boundary	Net Depletion At Val Marie
		Observed	Observed	12+13	Measured	Measured	Measured	15+16+17	25% of 18	14+18−19	4.92 dam3/day +% of remainder	20−21
1	Feb 26–Mar 7										4	
2	Mar 8 – 17										4	
3	Mar 18 – 28										4	
4	Mar 29–Apr 7										6	
5	Apr 8 – 17										6	
6	Apr 18 – 27										6	
7	Apr 28–May 7										10	
8	May 8 – 17										10	
9	May 18 – 28										10	
10	May 29–Jun 7										16	
11	Jun 8 – 17										16	
12	Jun 18 – 27										16	
13	Jun 28–Jul 7										16	
14	Jul 8 – 17										16	
15	Jul 18 – 28										16	
16	Jul 29–Aug 7										16	
17	Aug 8 – 17										16	
18	Aug 18 – 28										16	
19	Aug 29–Sep 7										10	
20	Sep 8 – 17										10	
21	Sep 18 – 27										10	
22	Sep 28–Oct 7										6	
23	Oct 8 – 17										6	
24	Oct 18 – 28										6	

Environment Canada

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NATURAL FLOW OF FRENCHMAN RIVER AT INTERNATIONAL BOUNDARY FOR THE YEAR 19__

All quantities in cubic decametres

		23	24	25	26	27	28	29	30
Period	Period at International Boundary	Net Depletion In Canada	Frenchman River At International Boundary	Apparant Natural Flow Of Frenchman River	Adjustment For Minor Diversions And Domestic Use	Natural Flow Of Frenchman River	U.S.A. Share Of Natural Flow	Excess Flow To The U.S.A.	Deficit(−) To Date
		5+11+22	Measured	23+24	Estimated	25+26	50% of 27	24−28	Sum Of 29
1	Mar 1 – 10								
2	Mar 11 – 20								
3	Mar 21 – 31								
4	Apr 1 – 10								
5	Apr 11 – 20								
6	Apr 21 – 30								
7	May 1 – 10								
8	May 11 – 20								
9	May 21 – 31								
10	Jun 1 – 10								
11	Jun 11 – 20								
12	Jun 21 – 30								
13	Jul 1 – 10								
14	Jul 11 – 20								
15	Jul 21 – 31								
16	Aug 1 – 10								
17	Aug 11 – 20								
18	Aug 21 – 31								
19	Sep 1 – 10								
20	Sep 11 – 20								
21	Sep 21 – 30								
22	Oct 1 – 10								
23	Oct 11 – 20								
24	Oct 21 – 31								

APPENDIX F

COPIES OF CORRESPONDENCE REGARDING BORDER CROSSING PRIVILEGES

Water Resources Division
Federal Building, Room 428
301 South Park Avenue, Drawer 10076
Helena, Montana 59626-0076

June 16, 1987

Mr. Norm Mercer, Chief Patrol Agent
U.S. Border Patrol Sector Headquarters
P.O. Box 112
Havre, Montana 59501

Dear Mr. Mercer:

I recently discussed crossing the United States-Canadian border at points other than official ports-of-entry with Mr. Lohman of your staff. Attached is a copy of a response to a similar request from the U.S. Geological Survey and Water Survey of Canada for such permission in the headwaters of the Milk River drainage. I realize you are not bound by decisions made outside your jurisdiction, but perhaps you will consider a similar pragmatic approach to our request to make crossings at Battle Creek, Lyons Creek, and Frenchman River.

Because the Boundary Waters Treaty of 1909 directed the monitoring of streams at points where they cross the international boundary, water resources agencies of both the United States and Canada have shared the responsibility of maintaining many stream-gaging stations located within yards north or south of the 49th parallel. Due to the distances and traveling times to ports-of-entry, the desolation of the countryside, and the attractiveness of "border gates," we have made frequent crossings at such gates throughout the years. Border-crossing agencies of both countries have been aware of our activities in general, and we have attempted to keep them notified on a trip-by-trip basis of specific transboundary movements. Because we are federal agencies, both the U.S. Geological Survey and Water Survey of Canada have felt the obligation to act as watchdogs and report any signs of boundary crossings at these remote sites.

We would very much like to continue to receive the special crossing privileges which we have enjoyed in the past. We are willing to provide more prompt and accurate information to maintain this privilege so we can continue to do our jobs in the most efficient manner possible.

Please advise us of any additional information you may need. Thank you for your consideration.

Sincerely,

David B. Hanson
Hydrologist

Attachment

cc: Eldon Garvis, Willow Creek Border Station, United States
Ken Ealey, Willow Creek Border Station, Canada

DBH:phh

Revenue Canada Customs and Excise
Revenu Canada Douanes et Accise

Box 2910,
720 Harry Hays Building,
220-4th Avenue S.E.,
Calgary, Alberta. T2P 2M7

W. S. of C. - CALGARY
MAY 27 1983
FILE No. 5370-3/MSM-1

ACTION	INITIALS
GHM	

Your file Votre référence
Our file Notre référence C8100-1

May 25th, 1983

Environment Canada,
Water Resources Branch,
Inland Waters Directorate,
Bag 2909, Postal Station "M",
CALGARY, Alberta. T2P 2M7

Attention: G.H. Morton, Regional Chief,
Alberta District

Dear Mr. Morton:

This refers to your letter of April 26th, 1983 addressed to Mr. Theodore, Manager, Southern Alberta Operations, requesting authorization to enter Canada without formal Canada Customs clearance. Mr. Theodore has briefed me on your requirements and I have considered your request.

Please accept this letter as authority for employees of your Department and the United States Geological Survey, on a standing basis, to report verbally to Canada Customs at Carway, Alberta as follows:

(1) Employees of your Department will telephone Canada Customs in Carway at 653-3009 each time a trip is required prior to leaving Canada. If a project involves a number of consecutive days, only one report will be required with an estimate of the number of days involved.

(2) Employees of the United States Geological Survey will telephone Canada Customs in Carway at 403-653-3009 each time a trip is required prior to entering Canada. Again, if a project involves a number of consecutive days, only one report will be required with an estimate of the number of days involved.

(3) This authority is only applicable when the International movement of an employee is directly related to the work being performed for each Department. This, of course, does not in any way negate the requirement of these employees to report to the United States Customs or Immigration Departments prior to leaving Canada.

. . . . 2

It is important that the reporting instructions are followed as the area is patrolled by the R.C.M.P., and a non-report would cause considerable problems. If you are considering putting a lock on one of the gates, we will not be responsible for its maintenance. In either case, we will not require a key.

Yours truly,

Al Lentz

A.L. LENTZ,
Regional Collector,
Customs and Excise,
Alberta Region.

UNITED STATES DEPARTMENT OF JUSTICE
IMMIGRATION & NATURALIZATION SERVICE
301 SO. PARK, ROOM NO. 512
FEDERAL OFFICE BLDG. - DRAWER 10036
HELENA, MONTANA 59626

PLEASE ADDRESS REPLY TO
MARVIN D. MOHRMAN

AND REFER TO THIS FILE NO.
HEL 235-C

July 24, 1987

Mr. David B. Hanson
United States Department of the Interior
Geological Survey
Water Resources Division Federal Building, Room 428
Federal Building, Room 428
301 South Park Avenue, Drawer 10076
Helena, Montana 59626-0076

Dear Mr. Hanson:

This has reference to your request of June 16, 1987, through the Chief Patrol Agent, U.S. Border Patrol, Havre, Montana, for special border crossing privileges at Battle Creek, Lyon Creek and Frenchman Creek. Such special privileges are approved subject to the following requirement:

1. That the names and dates of birth of the employees involved in the crossing be furnished this office. (Currently, the following employees are authorized special crossing privileges: David B. Hanson,Donald A. Bischoff and Norman A. Midtlyng)

2. That Canada Customs and Immigration also give approval.

3. That, prior to crossing into Canada, the respective U.S. ports of entry nearest the crossing sites be advised of the crossing, the names of the employees who will be crossing, and the time of this expected return to the United States. Your report in compliance with the U.S. Customs Service's approval of July 21, 1987. will serve a compliance with this Service's required report.

4. That the U.S. Border Patrol, Havre, Montana, be advised at (406) 265-6781, of each crossing into Canada and the time of the expected return to the United States.

The approval of these special border crossing privileges will be automatically terminated if at any time any of the other United States or Canadian agencies involved withdraw such privileges.

The importance of the reporting requirements can not be overly stressed. The reports are vital in order to forestall unnecessary expenditures of time and resources on the part of this Service.

Sincerely,

Marvin D. Mohrman
District Director

DEPARTMENT OF THE TREASURY
U.S. CUSTOMS SERVICE
GREAT FALLS, MONTANA

July 21, 1987

REFER TO BOR-2-0 JS

Mr. David B. Hanson
Hydrologist
United States Department of the Interior
Water Resources Division
Federal Building, Room 428
301 South Park Avenue, Drawer 10076
Helena, Montana 59626-0076

Dear Mr. Hanson:

The border crossing privileges that you request in your letter of July 8, 1987 are approved subject to the following:

1. That the names and dates of birth of the individuals involved in the crossings be furnished this office. (Currently, the following individuals are authorized crossing: David B. Hanson, Donald A. Bischoff, and Norman A. Midtlyng).
2. That Canada Customs and Immigration also gives their approval.
3. That the District Director, Immigration and Naturalization Service, Helena, Montana gives approval.
4. That prior to crossing into Canada, the respective U. S. port of entry be advised of the crossing, the names of the individuals involved, and the time of return to the U. S. (Crossings at Frenchman Creek - Port of Morgan; Battle Creek and Lyons Creek - Port of Willow Creek; Milk River - Port of Piegan). Also, the INS Border Patrol should be advised at telephone number (406) 265-6781.
5. That no merchandise is exported from or imported into the United States during the crossings.

It is important that reporting of the crossings be made as specified since the area is patrolled and failure to report will cause problems.

Sincerely yours,

J. Sharone

J. Sharone
Acting District Director

Revenue Canada
Customs and Excise

Box 2910, Station "M"
720 Harry Hays Building
220 - 4 Avenue S.E.
Calgary, Alberta
T2P 2M7

Revenu Canada
Douanes et Accise

CP 2910 Succ postale "M"
720 Immeuble Harry Hays
220 - sud-est 4e avenue
Calgary, Alberta
T2P 2M7

September 9th, 1987

Our file Votre référence C8100-1

Your file Notre référence

Mr. Brian Yee,
Boundary Waters Engineer,
Water Resources Branch,
Environment of Canada,
#210, 1102 - 8th Avenue,
REGINA, Saskatchewan.
S4R 1C9

Dear Mr. Yee:

Subject: Request for Border Crossing Privileges - WSC and USGS Personnel

This refers to your letter of August 28, 1987 addressed to Mr. D.J. Theodore, Southern Alberta District, requesting authorization to enter Canada without formal Canada Customs clearance.

Please accept this letter as authority for employees of the Water Survey of Canada (WSC) and the United States Geological Survey (USGS), on a standing basis, to report verbally to Canada Customs at the nearest Customs office as follows:

Frenchman River - Monchy, Saskatchewan (306) 298-2232
Battle Creek - Willow Creek, Saskatchewan (406) 398-5522
Lyons Creek - Willow Creek, Saskatchewan (406) 398-5522
Milk River - Carway, Alberta - (403) 653-3009

1. Employees of your Department will telephone the nearest Canada Customs office at the telephone numbers noted above each time a trip is required prior to leaving Canada. If a project involves a number of consecutive days, only one report will be required with an estimate of the number of days involved.

2. Employees of the United States Geological Survey will telephone the nearest Canada Customs office at the telephone numbers noted above each time a trip is required prior to entering Canada. If a project involves a number of consecutive days, only one report will be required with an estimate of the number of days involved.

. . . . 2

Request for Border Crossing Privileges (Continued)

3. This authority is only applicable when the International movement of an employee is directly related to the work being performed for each Department. This, of course, does not in any way negate the requirement for these employees to report to the U.S. Customs or Immigration Departments prior to leaving Canada.

It is important that these reporting instructions are followed as the area is patrolled by the R.C.M. Police, and non-report could cause considerable problems.

This approval will be automatically terminated if the United States authorities withdraw such privileges.

I trust this arrangement meets with your approval.

Yours truly,

Roger J Kohut

for A.L. LENTZ,
Regional Collector,
Department of National Revenue,
(Customs and Excise),
Alberta Region.

Government of Canada Gouvernement du Canada

MEMORANDUM NOTE DE SERVICE

TO
A
D. Turgeon
International Area Supervisor
WSC, Regina

FROM
DE
W.R. Klassen
Hydrometric Technician
WSC, Shaunavon

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE
5900/3

YOUR FILE/VOTRE RÉFÉRENCE

DATE
1988-04-20

SUBJECT
OBJET
Crossing the International Boundary at Uncontrolled Crossing South of Val Marie

During a conversation with the Canadian Customs Officer at the Monchy post, the following procedure was suggested:

Before starting the trip:

1. Phone Canada Customs at Monchy (298-2232) to notify them of your trip plans. (Where your crossing the boundary and when).

2. Phone the U.S. Border Patrol in:
   - Malta, Mont. 406-654-2711 (only a one person office, can leave a message on machine - no longer than 2 minutes)

or - Havre, Mont. 406-265-6781 (24 hour service).

- Tell them who you are, with WRB, when and where you are crossing. They have a description of my vehicle and will want the description of any other type of vehicle being used.

3. It is probably not necessary to contact the RCMP in Val Marie prior to the trip. If stopped and questioned by them, have the letter handy explaining our border crossing privilages and tell them you have notified Canada Customs of your trip.

W.R. Klassen

cc: W. Wyatt
W. Klassen
B. Yee
D. Turgeon
R. Herrington
B. Johnson
J. Chubak

APPENDIX G

PREPARATION OF THE ANNUAL REPORT TO THE IJC

The following is a summary of the activities required for preparation of the annual report to the IJC:

OCTOBER

1. Send four copies of the letter of transmittal for signature by the Accredited Officer of the United States.

2. Send letters to Water Rights Branch, Alberta Environment and Sask Water requesting minor diversion usage information.

3. Send memo/letter to USGS, Helena and WRB, Regina and Calgary requesting map and distribution list changes.

NOVEMBER

4. After the signature of the Accredited Officer for the United States is received, send the four letters for signature by the Accredited Officer of Her Majesty.

5. Revise map as necessary. The map is in AutoCad format and is stored in the computer of the AutoCad operator in IWD, Regina.

6. Revise distribution list as necessary.

DECEMBER

7. Initial revision of the report narrative (WITHOUT the numbers). Discuss revisions with appropriate Canadian or American counterpart. Submit agreed upon revisions to the office preparing the IJC Report.

8. Update the month-end reservoir contents (Appendix B, Table 16 and the chart - IJC Report, Figure 3).

9. Prepare signing copies of all annual listings for international gauging stations.

JANUARY

10. Compute natural flows (Appendix A - Tables 6, 8, 10, 12, 14)

11. Update all natural flow summary tables (IJC Report - Tables 1, 2, 3, 4, 5; Appendix A - Tables - 7, 9, 11, 13, 15).

12. Update all natural flow summary bar charts (IJC Report - Figures 1, 2, 4, 5, 6)

13. Prepare report narrative WITH the numbers.

14. Obtain print-ready records at the annual meeting of the Field Representatives.

FEBRUARY

15. Final editing and revision of the report narrative (with the numbers).

16. FAX or courier the final draft of the report to the Field Representatives for review and comment.

17. Assemble print-ready manuscripts. Number all pages.

18. Give print-ready manuscripts to printer.

19. Receive and check printed volumes for errors.

20. Correct errors.

MARCH

21. Prepare cover letter, package, and distribute reports before March 15.

APPENDIX H

DISTRIBUTION LIST - ANNUAL REPORT TO THE IJC

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Mr. Philip Slyfield Secretary, Canadian Section International Joint Commission 18th Floor, Berger Building 100 Metcalfe Street Ottawa, Ontario Canada K1P 5M1	2	12	2
Mr. David LaRoche Secretary, United States Section International Joint Commission 2001 S. Street N.W. Washington, D.C. U.S.A. 20440	2	12	4
Mr. D. R. Kimmett Director Water Resources Branch Inland Waters Directorate Environment Canada Ottawa, Ontario Canada K1A 0H3	0	1	1
Mr. R. A. Halliday Regional Director Inland Waters Directorate Environment Canada Park Plaza #300 - 2365 Albert St. Regina, Saskatchewan Canada S4P 4K1	0	2	1
Mr. D. A. Davis Director General Inland Waters Directorate Environment Canada Ottawa, Ontario Canada K1A 0H3	0	2	2
Mr. Philip Cohen Chief Hydrologist United States Geological Survey 12201 Sunrise Valley Drive Reston, VA U.S.A. 22092	0	1	1

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Mr. Joe A. Moreland District Chief United States Geological Survey Room 428, Federal Building 301 South Park Avenue, Drawer 10076 Helena, MT U.S.A. 59626	0	5	5
Mr. J. F. Blakey Regional Hydrologist United States Geological Survey Water Resources Division M.S. 406, Box 25046 Denver Federal Center Lakewood, CO U.S.A. 80225	0	1	0
Mr. B. Burns Regional Director General Conservation and Protection Environment Canada Twin Atria #2, 2nd Floor 4999-98th Avenue Edmonton, Alberta Canada T6B 2X3	0	1	1
Mr. G. H. Morton Regional Chief Water Resources Branch Inland Waters Directorate Environment Canada Bag 2909, Pstl. Stn. "M" Calgary, Alberta Canada T2P 2M7	0	3	3
Mr. R. G. Boals Regional Chief Water Resources Branch Environment Canada #300 - 2365 Albert St. Regina, Saskatchewan Canada S4P 4K1	0	6	6

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Mr. D. L. MacLeod Vice-President, Water Management Saskatchewan Water Corp. Victoria Place 111 Fairford Street East Moose Jaw, Saskatchewan Canada S6H 7X9	0	2	1
Mr. P. Melnychuk Assistant Deputy Minister Alberta Environment Oxbridge Place, 10th Floor 9820-106th Street Edmonton, Alberta Canada T5K 2J6	0	2	1
Dr. H. Hill Director General, PFRA Department of Agriculture Rm 401, Motherwell Building 1901 Victoria Avenue Regina, Saskatchewan Canada S4P 0R5	0	1	2
Mr. Bill Duncan Southwest Regional Manager Saskatchewan Water Corp. E.I. Wood Building 350 Cheadle Street West Swift Current, Saskatchewan Canada S9H 4G3	0	1	1
Mr. R. Kellow Executive Director PPWB Secretariat #201 - 2050 Cornwall St. Regina, Saskatchewan Canada S4P 2K5	0	1	2
Mr. John G. Anderson Attn: W-5120 U.S. Bureau of Reclamation Department of the Interior 18th & C Streets Washington, D.C. U.S.A. 20240	0	5	0

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Irrigation Manager U.S. Bureau of Reclamation P. O. Box 700 Malta, MT. U.S.A. 59538-0700	0	1	1
Mr. R. Williamson Irrigation Supervisor SW Irrigation Projects PFRA Box 1088 Swift Current, Saskatchewan Canada S9H 3X3	0	1	1
Mr. Don Kissell Project Manager Consul Irrigation Project PFRA Consul, Saskatchewan Canada S0N 0P0	0	1	1
Mr. Roger Humphries Project Manager Eastend Irrigation Project PFRA Box 146 Eastend, Saskatchewan Canada S0N 0T0	0	1	1
Mr. Ray Schultz Project Manager Val Marie Irrigation Project PFRA Box 118 Val Marie, Saskatchewan Canada S0N 2T0	0	1	1
Mrs. Carrie Funk Secretary-Treasurer Vidora Water Users Association Box 185 Consul, Saskatchewan Canada S0N 0P0	0	1	1

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Mr. A. D. Dydik Alberta Water Resources 535-30th Street N. Lethbridge, Alberta Canada T1J 4C7	0	2	2
Mr. G. Fritz Administrator Water Resources Division Montana Department of Natural Resources and Conservation 1520 East 6th Avenue Helena, MT. U.S.A. 59620	0	2	2
Regional Director Attn: GP 450 U. S. Bureau of Reclamation P. O. Box 36900 Billings, MT. U.S.A. 59107-6900	0	2	2
Mrs. Jean Jones Secretary Lodge Creek Water Users Association Site 2, Box 7 Consul, Saskatchewan Canada S0N 0P0	0	1	1
Mr. R. Delk U.S. Bureau of Indian Affairs 316 North 26th Street Billings, MT. U.S.A. 59101	0	1	1
Environment Canada Departmental Library Ottawa, Ontario Canada K1A 0H3	0	1	1
Alberta Environment Library 14th Floor, Oxbridge Place 9820 - 106th Street Edmonton, Alberta Canada T5K 2J6	0	1	1

Name and Address	Original Signatures	Photocopy Signatures	Appendices A & B
Mr. Jim Wedeward Project Manager Attn: MT-450 U.S. Bureau of Reclamation P. O. Box 30137 Billings, MT U.S.A. 59107-0137	0	2	2
Mr. J. Masyk District Superintendent Canadian Parks Service Grasslands National Park Box 1050 Val Marie, SK Canada S0N 2T0	0	1	0
Total	4.00	77.00	51.00

APPENDIX I

CHECK LIST FOR INTERIM APPORTIONMENT REPORTS ON THE EASTERN TRIBUTARIES OF THE MILK RIVER

CHECK LIST FOR INTERIM APPORTIONMENT REPORTS ON THE EASTERN TRIBUTARIES OF THE MILK RIVER

F = Frenchman B = Battle L = Lodge R = Reservoir month-end chart and table

	R.A. Halliday	Bill Duncan Sask Water Swift Current (Requests all pages of natural flow computations be sent)	Fred Martin Hydrology Div. PFRA Regina	Richard Kellow PPWB Regina	Dave Hanson USGS Helena	Reg Williamson PFRA Swift Current	Don Kissell PFRA Consul, SK S0N 0P0	Ron Deeprose Technical Services Alberta Environment Oxbridge Place 9820 - 106th St. Edmonton, Alta. T5K 2J6	Forecast Centre Sask Water Moose Jaw	Gerry Morton WRB Calgary	Wayne Klassen WRB Shaunavon
Division	in-office	fax (306)778-8271	messenger	messenger	fax (406)449-5497	fax (306)773-2359	mail	mail	IWD direct mail	IWD direct mail	IWD direct mail
1	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
2	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
3	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
4	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
5	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
6	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
7	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
8	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
9	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
10	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
11	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
12	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
13	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
14	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
15	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
16	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
17	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
18	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
19	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
20	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
21	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R
22	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
23	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L	F B L
24	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R	F B L R

CHECK LIST FOR INTERIM APPORTIONMENT REPORTS ON THE EASTERN TRIBUTARIES OF THE MILK RIVER

F = Frenchman B = Battle L = Lodge R = Reservoir month-end chart and table

	Russ Boals	Regional Engineer, Regional Hydrologist, Boundary Waters Engineer	Roger Humphries Project Manager PFRA Box 146 Eastend, SK S0N 0T0	Ray Schultz Project Manager PFRA Box 118 Val Marie, SK S0N 2T0	J.D. Wilkins USBR P.O. Box R Malta, Montana USA 59538	R.M. Bennett Regional Administrator Alberta Environment #200 - 5th Ave. Lethbridge, Alta. T1J 4C7	A.R. Strome Alberta Environment 10th Floor Oxbridge Place 9820 - 106th St. Edmonton, Alta. T5K 2J6	L.B. Chambers Director Soil & Water Conservation PFRA Regina	Heather Bierbach Middle Creek Water Users R.R. 1 Maple Creek, SK S0N 1N0	Jean Jones Lodge Creek Water Users Site 2, Box 7 Consul, SK S0N 0P0	Number of copies required
Division	in-office	in-office	mail	mail	mail	mail	mail	messenger	mail	mail	
1	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	Month-end F = 14 B = 12 L = 14 R = 19
2	F B L	F B L	F	F							
3	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
4	F B L	F B L	F	F							
5	F B L	F B L	F	F							
6	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
7	F B L	F B L	F	F							Normal F = 13 B = 11 L = 11
8	F B L	F B L	F	F							
9	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
10	F B L	F B L	F	F							
11	F B L	F B L	F	F							
12	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
13	F B L	F B L	F	F							
14	F B L	F B L	F	F							
15	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
16	F B L	F B L	F	F							
17	F B L	F B L	F	F							
18	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
19	F B L	F B L	F	F							
20	F B L	F B L	F	F							
21	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	
22	F B L	F B L	F	F							
23	F B L	F B L	F	F							
24	F B L R	F B L R	F R	F R	F B L R	L R	L R	R	R	R	

APPENDIX J

LIST OF CONTACTS

The following is a list of contacts used by the USGS and WRB used for water management during the irrigation season.

USGS, HELENA

Bob Larson or Marv Cross
Montana Department of Natural Resources
Havre, MT ph. 265-5516

Duane Skoyan
Lodge Creek Water Users Association
Chinook, MT ph. 357-3554

Russ Unruh
Battle Creek Water Users Association
Chinook, MT ph. 357-3628

Gus Yeska
Frenchman River Water Users Association
Saco, MT ph. 648-5483

WRB, Calgary

Dick Bennett
Regional Administrator, Alberta Environment
Lethbridge, AB ph. (403)329-5329

Andrew Cullen
Manager, Alberta Regional Division, PFRA
Calgary, AB ph. (403)292-5641

Bill Kuhnke
River Forecast Centre, Alberta Environment
Edmonton, AB ph. (403)427-6278

WRB, Regina

Bill Duncan or Terry Paul
SW Regional Manager/SW District Supervisor, Sask Water
Swift Current, SK ph.(306)778-8257 fax. 778-8271

Roger Humphrey
Project Manager, Eastend Irrigation Projects, PFRA
Eastend, SK ph.(306)295-3252

Don Kissell
Project Manager, Consul Irrigation Projects, PFRA
Consul, SK ph.(306)299-2040

Hamid Rahim
Southern Basins Allocation Manager, Surface Water Rights Branch,
Alberta Environment
Edmonton, AB ph.(403)427-6111

Ray Schultz
Project Manager, Val Marie Irrigation Projects, PFRA
Val Marie, SK ph.(306)298-2131

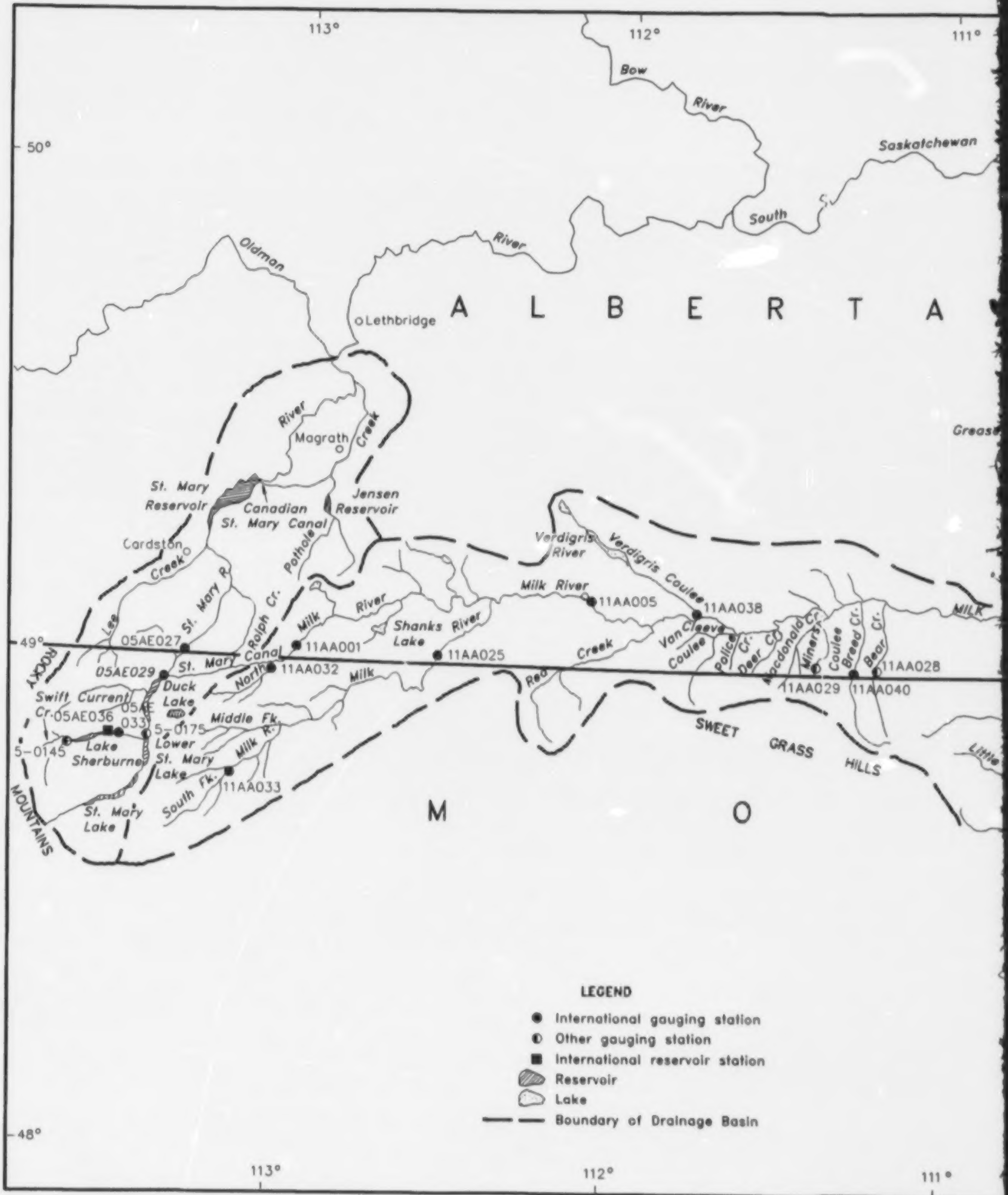
Tom Tang
River Forecast Centre, Alberta Environment
Edmonton, AB ph.(403)427-6278 fax.422-9333

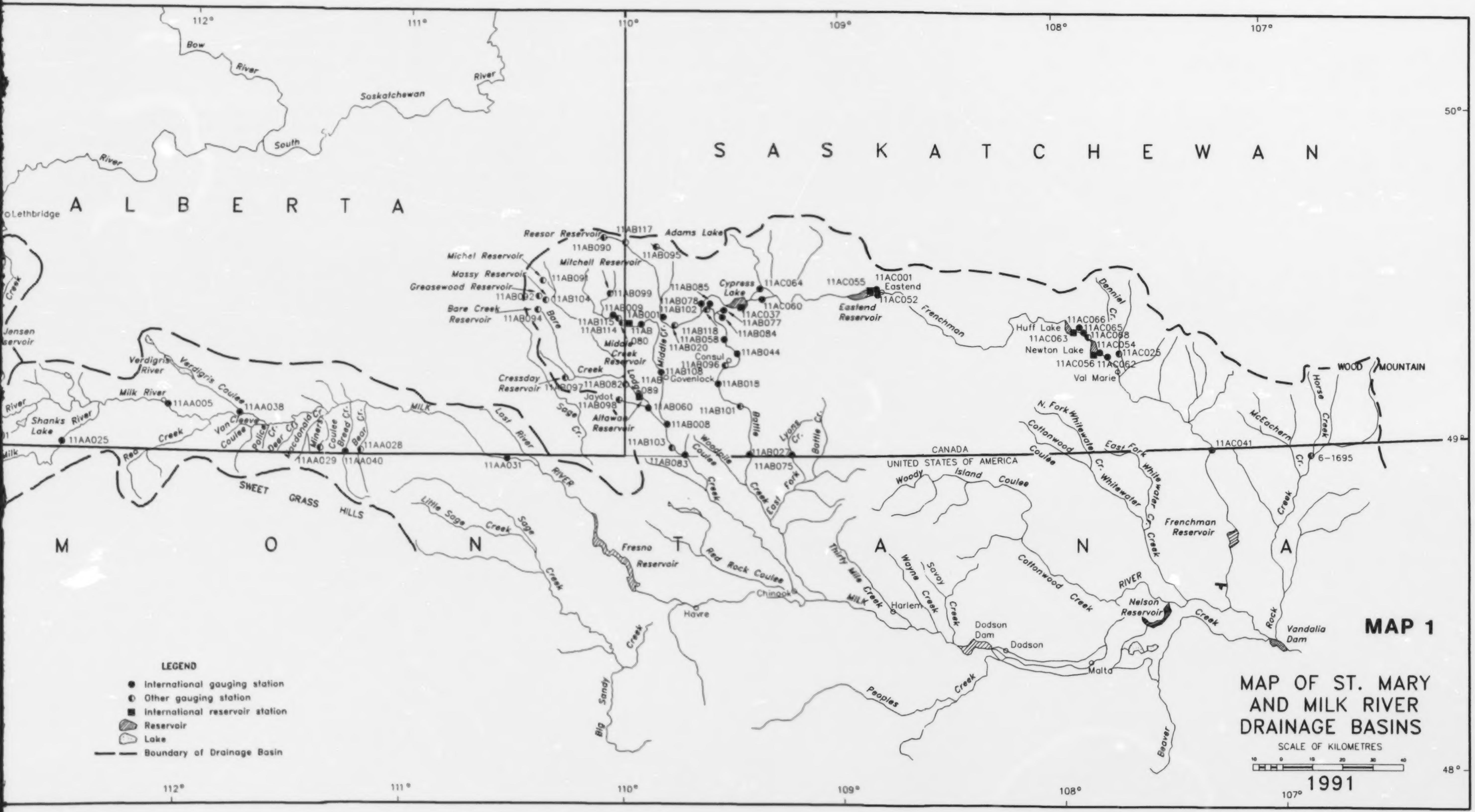
Reg Williamson
SW Irrigation Supervisor, PFRA
Swift Current, SK ph. (306)773-7255 fax. 773-2359

APPENDIX K

MAPS

1. Map of St. Mary and Milk River Drainage Basins
2. Lodge Creek Basin in Canada
3. Battle Creek Basin in Canada
4. Frenchman River Basin in Canada
5. Schematic Map St. Mary River Basin
6. Schematic Map Milk River Basin
7. Schematic Map Lodge Creek Basin in Canada
8. Schematic Map Battle Creek Basin in Canada
9. Schematic Map Frenchman River in Canada

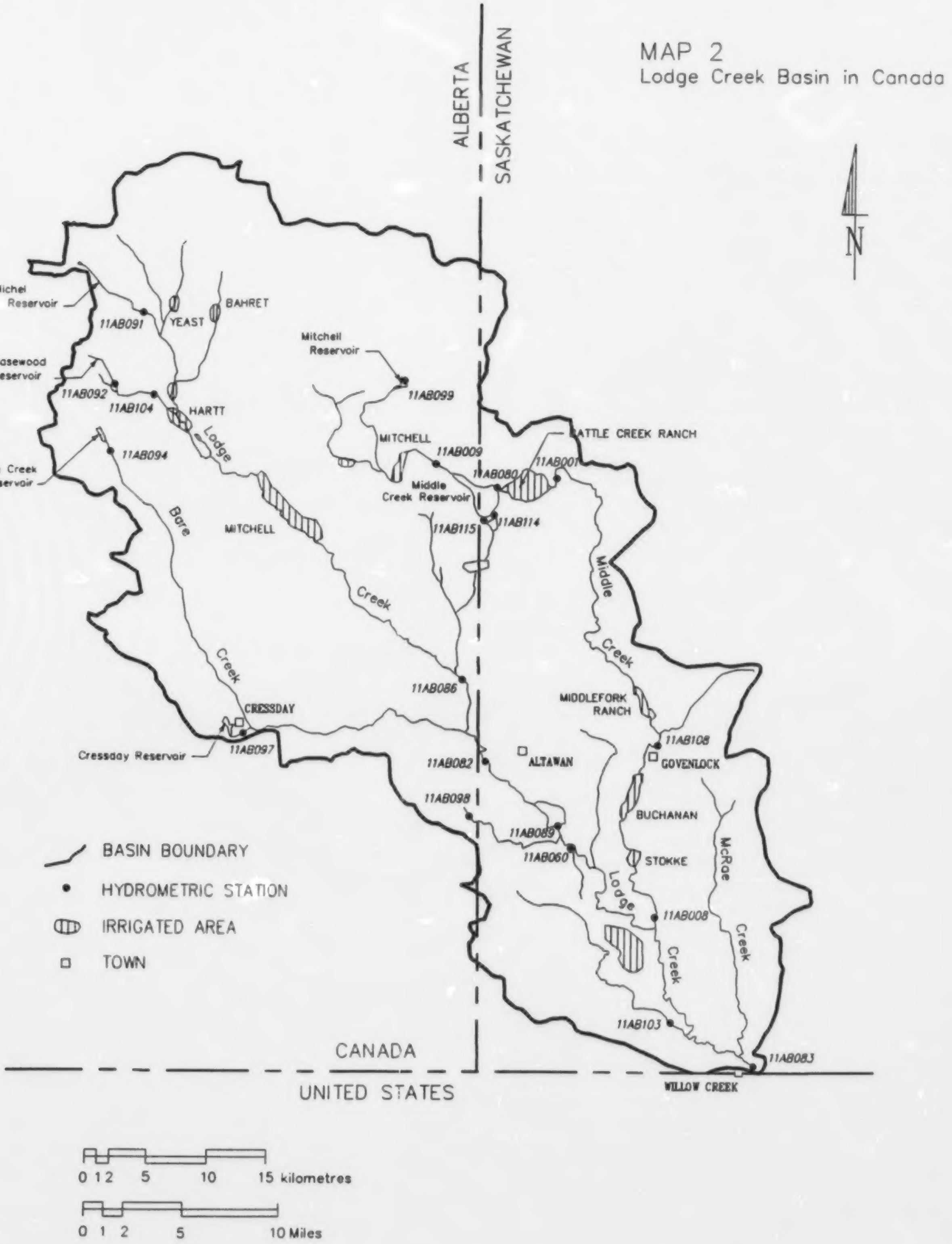

113°
112°
111°
50°
49°
48°
Bow River
Saskatchewan
South
Oldman
River
Lethbridge
A L B E R T A
Grease
River
Magrath
Creek
St. Mary Reservoir
Canadian St. Mary Canal
Jensen Reservoir
Cardston
Creek
Lee
St. Mary R.
Pothole
Rolph Cr.
Verdigris River
Verdigris Coulee
Milk River
11AA005
11AA038
Milk
River
Shanks Lake
River
11AA001
11AA025
05AE027
St. Mary
Canal
North
11AA032
Milk
Red
Creek
Van Cleeve Coulee
Police Cr.
Deer Cr.
Macdonald Cr.
Miners Coulee
Breed Cr.
Bear Cr.
11AA028
11AA029
11AA040
MILK
ROCKY MOUNTAINS
05AE029
Duck Lake
Swift Current Cr.
05AE036
05AE033
5-0175
5-0145
Lake Sherburne
Lower St. Mary Lake
Middle Fk.
Milk R.
South Fk.
11AA033
St. Mary Lake
SWEET GRASS HILLS
Little
M O
LEGEND
● International gauging station
◐ Other gauging station
■ International reservoir station
▨ Reservoir
○ Lake
— — Boundary of Drainage Basin


ALBERTA
SASKATCHEWAN
MONTANA
CANADA
UNITED STATES OF AMERICA
112°
111°
110°
109°
108°
107°
50°
49°
48°
oLethbridge
Bow River
South Saskatchewan River
Jensen Reservoir
Verdigris River
Verdigris Coulee
Milk River
Shanks Lake
11AA025
11AA005
11AA038
11AA028
11AA029
11AA040
11AA031
Van Cleeve Coulee
Police Cr.
Deer Cr.
Macdonald Cr.
Miners Coulee
Breed Cr.
Bear Cr.
Red Creek
SWEET GRASS HILLS
MILK RIVER
Lost River
Reesor Reservoir
Michel Reservoir
Massy Reservoir
Greasewood Reservoir
Bare Creek Reservoir
Mitchell Reservoir
Middle Creek Reservoir
Cressday Reservoir
Altawan Reservoir
Adams Lake
Cypress Lake
11AB117
11AB090
11AB095
11AB091
11AB092
11AB104
11AB099
11AB094
11AB009
11AB001
11AB115
11AB114
11AB080
11AB085
11AB078
11AB102
11AB118
11AB058
11AB020
11AB108
11AB096
11AB044
11AB018
11AB097
11AB082
11AB089
11AB098
11AB060
11AB008
11AB101
11AB103
11AB083
11AB027
11AB075
Jaydot
Govenlock
Consul
Lodge Cr.
Middle Cr.
Sage Cr.
Bare Cr.
Creek
Battle Cr.
Lyons Cr.
Woodpile Coulee
Creek
East Fork
11AC064
11AC060
11AC037
11AC077
11AC084
11AC055
11AC001
Eastend
11AC052
Eastend Reservoir
Frenchman
Huff Lake
Newton Lake
11AC066
11AC065
11AC063
11AC068
11AC054
11AC025
11AC056
11AC062
Val Marie
Denniel Cr.
WOOD MOUNTAIN
Horse Creek
McEachern Cr.
11AC041
6-1695
N. Fork Whitewater
East Fork Whitewater Cr.
Cottonwood Coulee
Whitewater Cr.
Creek
Woody Island Coulee
Frenchman Reservoir
Rock Creek
Vandalia Dam
Little Sage Creek
Sage Creek
Fresno Reservoir
Red Rock Coulee
Chinook
Havre
Big Sandy Creek
Thirty Mile Creek
MILK
Harlem
Wayne Creek
Savoy Creek
Cottonwood Creek
RIVER
Nelson Reservoir
Creek
Dodson Dam
Dodson
Malta
Peoples Creek
Beaver Creek
LEGEND
● International gauging station
◐ Other gauging station
■ International reservoir station
▨ Reservoir
○ Lake
— — Boundary of Drainage Basin
SCALE OF KILOMETRES
10 0 10 20 30 40

MAP 1

MAP OF ST. MARY AND MILK RIVER DRAINAGE BASINS

1991

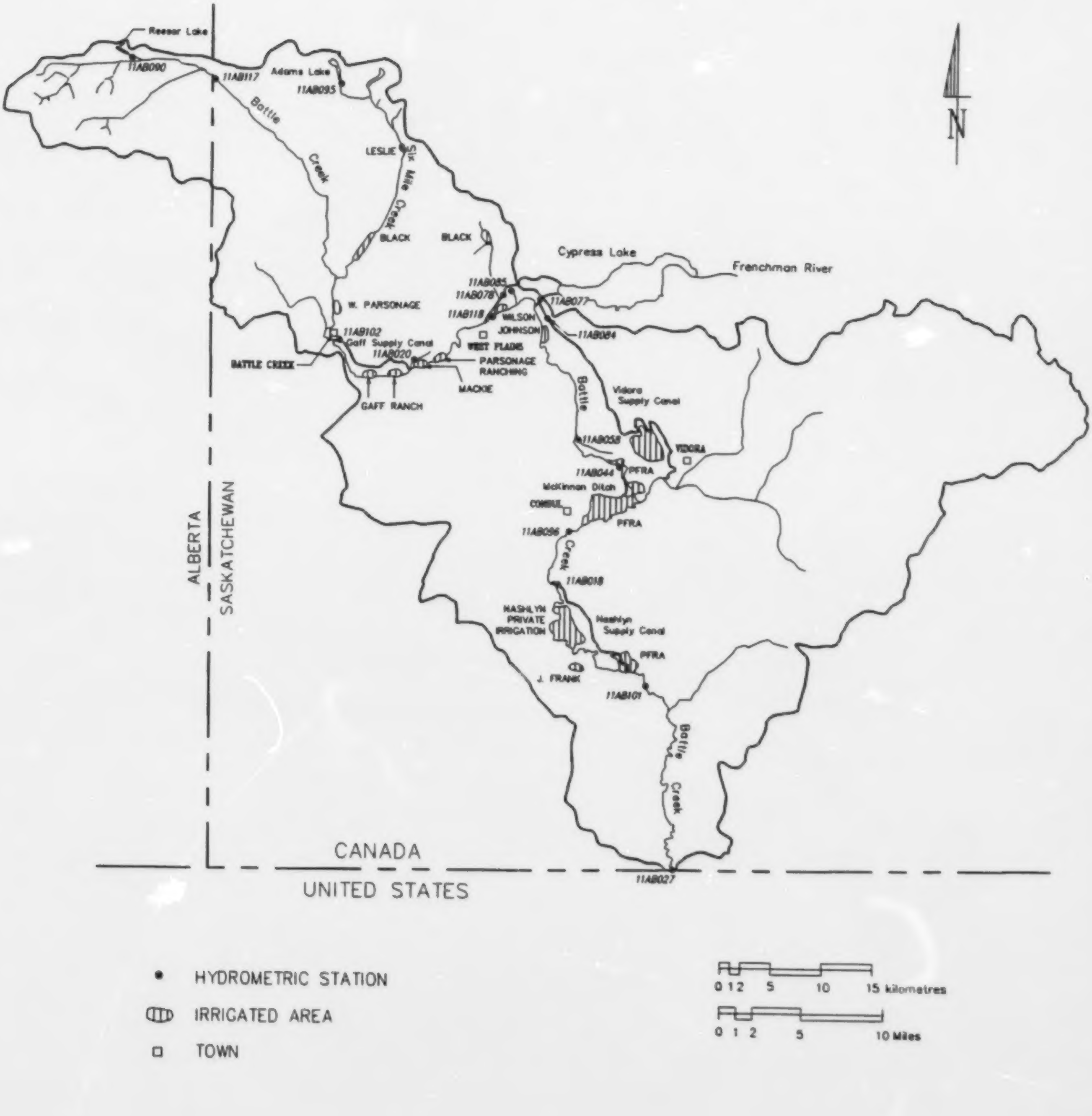


MAP 2
Lodge Creek Basin in Canada

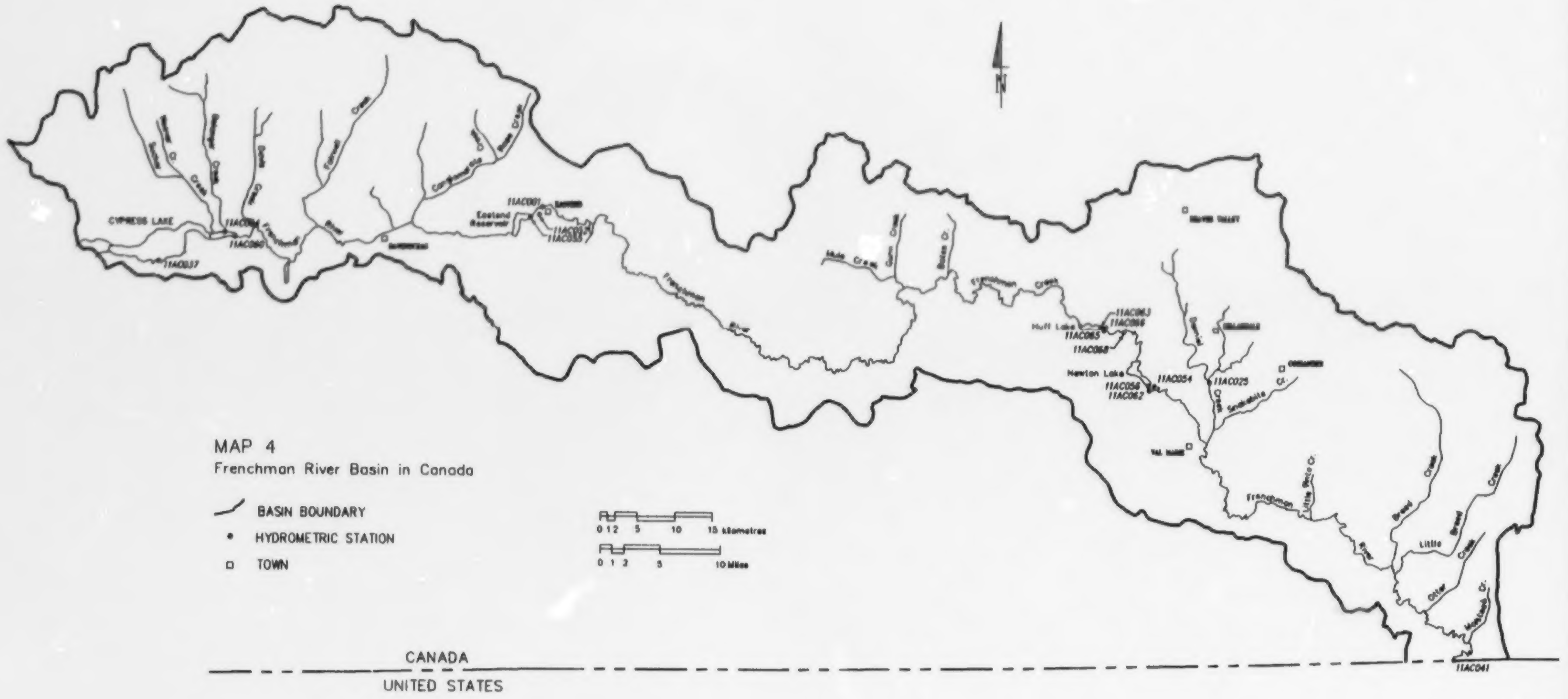
ALBERTA
SASKATCHEWAN
N
Michel Reservoir
11AB091
YEAST
BAHRET
Greasewood Reservoir
11AB092
11AB104
HARTT
Lodge
Bare Creek Reservoir
11AB094
Bare
Creek
MITCHELL
Creek
Mitchell Reservoir
11AB099
MITCHELL
11AB009
BATTLE CREEK RANCH
11AB080
11AB001
Middle Creek Reservoir
11AB115
11AB114
Middle
Creek
11AB086
CRESSDAY
Cressday Reservoir
11AB097
MIDDLEFORK RANCH
11AB108
GOVENLOCK
ALTAWAN
11AB082
11AB098
BUCHANAN
11AB089
11AB060
STOKKE
McRae
Creek
Lodge
Creek
11AB008
11AB103
11AB083
CANADA
UNITED STATES
WILLOW CREEK
BASIN BOUNDARY
HYDROMETRIC STATION
IRRIGATED AREA
TOWN
0 1 2 5 10 15 kilometres
0 1 2 5 10 Miles

MAP 3

Battle Creek Basin in Canada



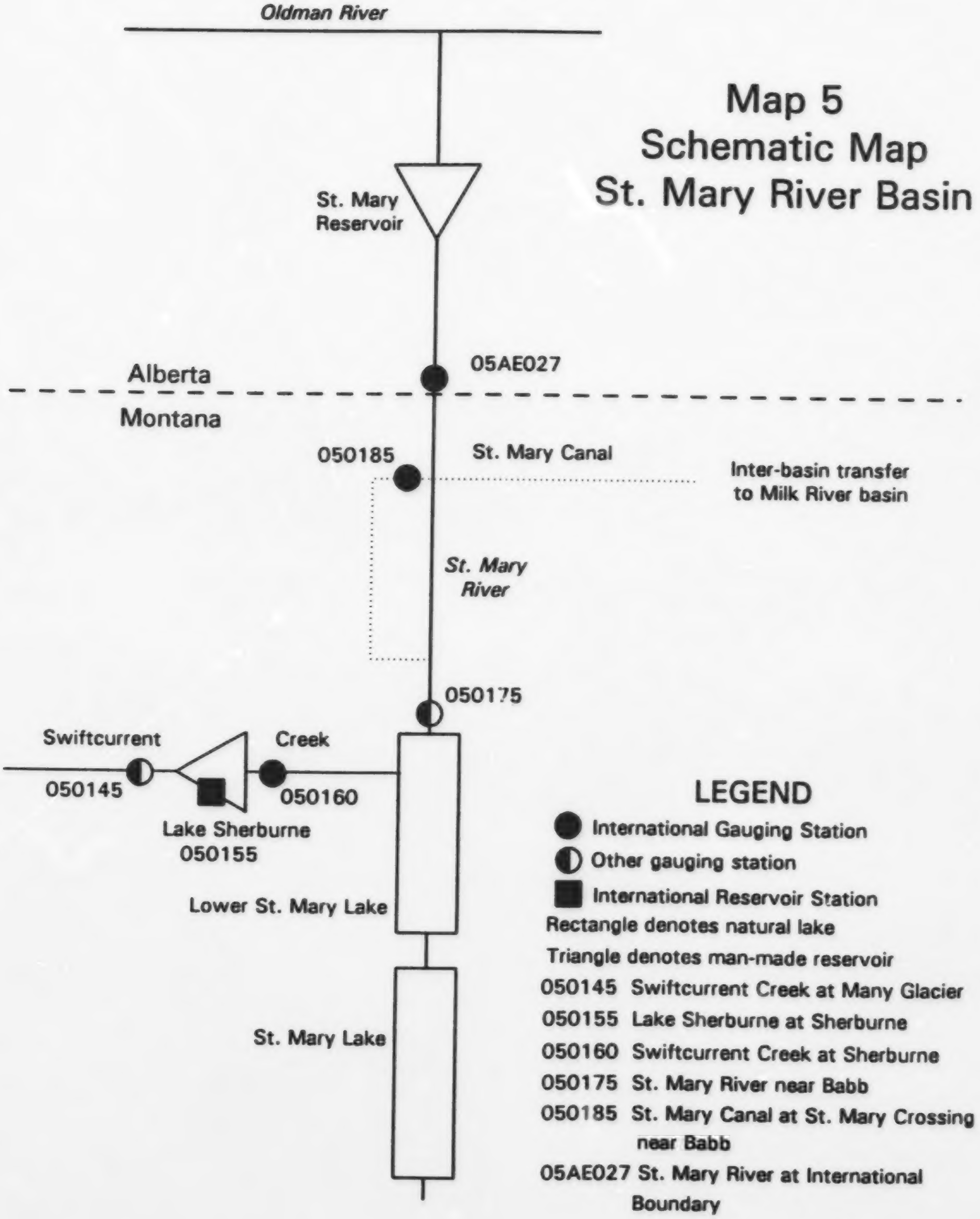
Reesor Lake
11AB090
11AB117
Adams Lake
11AB095
Battle
Creek
LESLIE
Six Mile Creek
BLACK
BLACK
Cypress Lake
Frenchman River
11AB085
11AB078
11AB118
WILSON
11AB077
JOHNSON
11AB084
W. PARSONAGE
11AB102
Gaff Supply Canal
11AB020
WEST PLAINS
PARSONAGE
RANCHING
BATTLE CREEK
MACKIE
GAFF RANCH
Battle
Vidora
Supply Canal
11AB058
VIDORA
11AB044
PFRA
McKinnon Ditch
CONSUL
PFRA
11AB096
Creek
11AB018
NASHLYN
PRIVATE
IRRIGATION
Nashlyn
Supply Canal
PFRA
J. FRANK
11AB101
Battle
Creek
ALBERTA
SASKATCHEWAN
CANADA
UNITED STATES
11AB027
N
HYDROMETRIC STATION
IRRIGATED AREA
TOWN
0 1 2 5 10 15 kilometres
0 1 2 5 10 Miles



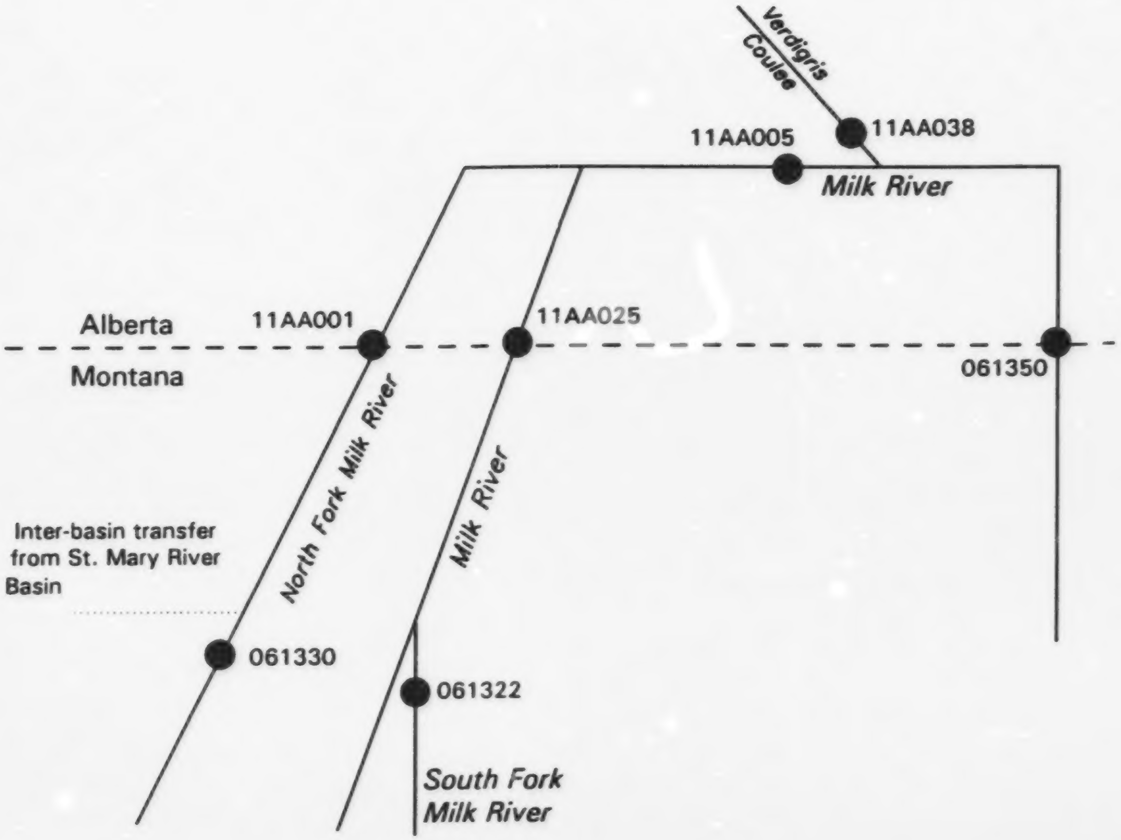
MAP 4
Frenchman River Basin in Canada

BASIN BOUNDARY
HYDROMETRIC STATION
TOWN
0 1 2 5 10 15 kilometres
0 1 2 5 10 Miles
N
CANADA
UNITED STATES
CYPRESS LAKE
11AC037
Creek
Frenchman
River
Eastend Reservoir
11AC001
Mule Creek
Bates Cr.
Frenchman Creek
Huff Lake
11AC063
11AC066
11AC065
11AC068
Newton Lake
11AC056
11AC062
11AC054
11AC025
Creek
Cr.
Frenchman
River
Breed Creek
Little Breed Creek
Otter Creek
Cr.
11AC041

Map 5
Schematic Map
St. Mary River Basin


Oldman River
St. Mary Reservoir
05AE027
Alberta
Montana
050185
St. Mary Canal
Inter-basin transfer to Milk River basin
St. Mary River
050175
Swiftcurrent
Creek
050145
050160
Lake Sherburne
050155
Lower St. Mary Lake
St. Mary Lake
LEGEND
● International Gauging Station
◐ Other gauging station
■ International Reservoir Station
Rectangle denotes natural lake
Triangle denotes man-made reservoir
050145 Swiftcurrent Creek at Many Glacier
050155 Lake Sherburne at Sherburne
050160 Swiftcurrent Creek at Sherburne
050175 St. Mary River near Babb
050185 St. Mary Canal at St. Mary Crossing near Babb
05AE027 St. Mary River at International Boundary

Map 6
Schematic Map
Milk River Basin


Verdigris Coulee
11AA038
11AA005
Milk River
Alberta
Montana
11AA001
11AA025
061350
North Fork Milk River
Milk River
Inter-basin transfer from St. Mary River Basin
061330
061322
South Fork Milk River

LEGEND

● International Gauging Station

061322	South Fork Milk River near Babb, Montana
061330	North Fork Milk River above St. Mary Canal near Browning, Montana
11AA001	North Milk River near International Boundary
11AA025	Milk River at Western Crossing of International Boundary
11AA005	Milk River at Milk River
11AA038	Verdigris Coulee near the Mouth
061350	Milk River at Eastern Crossing of International Boundary

11AB099	Mitchell Reservoir
11AB009	Middle Creek near Saskatchewan Boundary
11AB080	Middle Creek Reservoir
11AB114	Middle Creek Reservoir Bedford Outlet
11AB115	Middle Creek Reservoir Flood Spillway
11AB001	Middle Creek Below Middle Creek Reservoir
11AB108	Middle Creek near Govenlock
11AB008	Middle Creek above Lodge Creek
11AB086	Walburger Coulee below Diversions
11AB091	Michel Reservoir near Elkwater
11AB092	Greasewood Reservoir near Elkwater
11AB104	Massy Reservoir near Elkwater
11AB094	Bare Creek Reservoir near Elkwater
11AB097	Cressday Reservoir near Elkwater
11AB098	Jaydot Reservoir near Elkwater
11AB082	Lodge Creek near Alberta Boundary
11AB089	Altawan Reservoir near Govenlock
11AB060	Spangler Ditch near Govenlock
11AB103	Squaw Coulee near Willow Creek
11AB083	Lodge Creek below McRae Creek at International Boundary

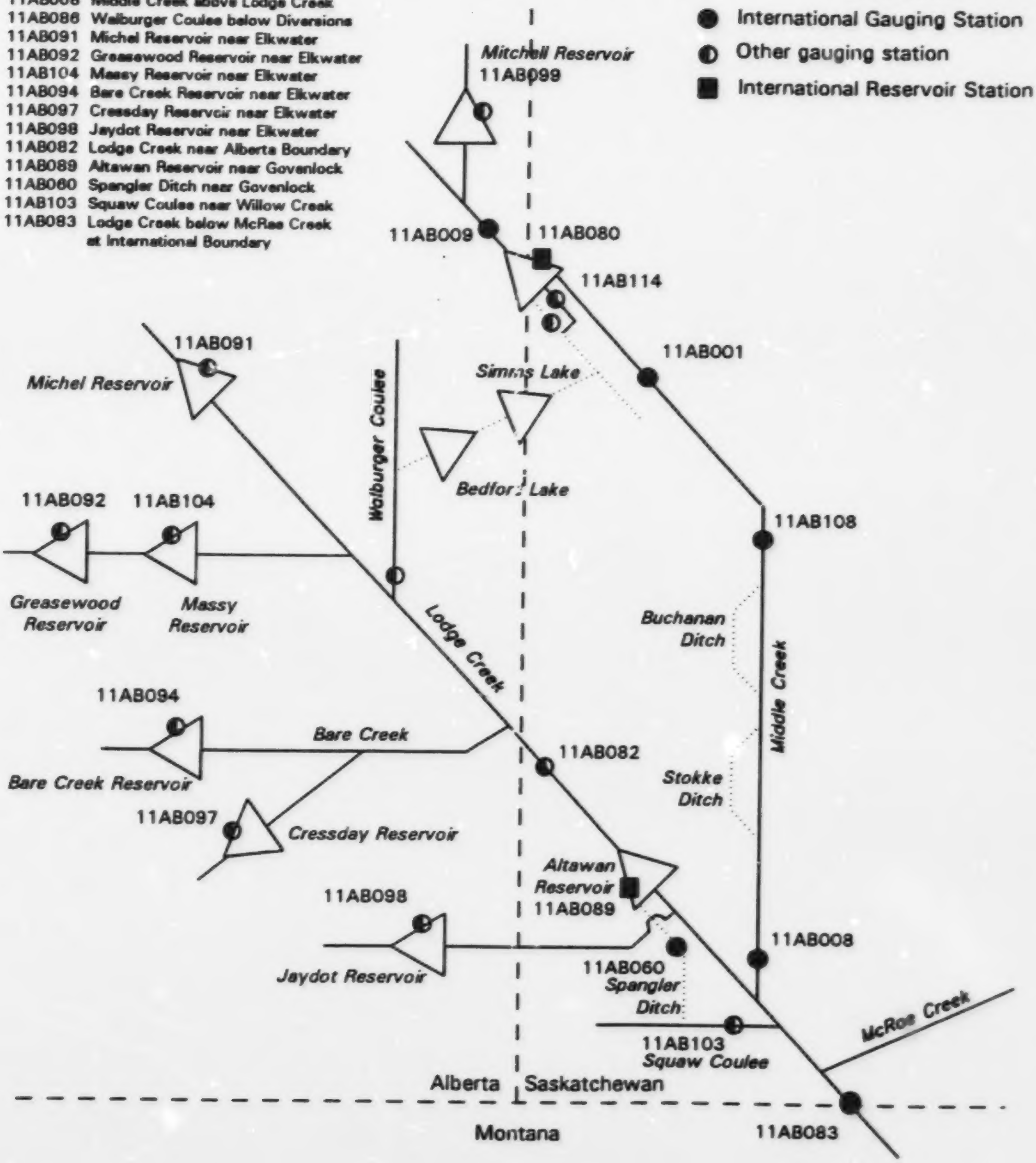
Map 7
Schematic Map
Lodge Creek Basin

LEGEND

● International Gauging Station

◐ Other gauging station

■ International Reservoir Station


Mitchell Reservoir
11AB099
11AB009
11AB080
11AB114
11AB001
11AB091
Michel Reservoir
Walburger Coulee
Simms Lake
Bedford Lake
11AB092
11AB104
Greasewood Reservoir
Massy Reservoir
11AB108
Lodge Creek
Buchanan Ditch
Middle Creek
11AB094
Bare Creek
Bare Creek Reservoir
11AB082
Stokke Ditch
11AB097
Cressday Reservoir
Altawan Reservoir
11AB089
11AB098
Jaydot Reservoir
11AB008
11AB060
Spangler Ditch
11AB103
Squaw Coulee
McRae Creek
Alberta
Saskatchewan
Montana
11AB083

Map 8
Schematic Map
Battle Creek Basin

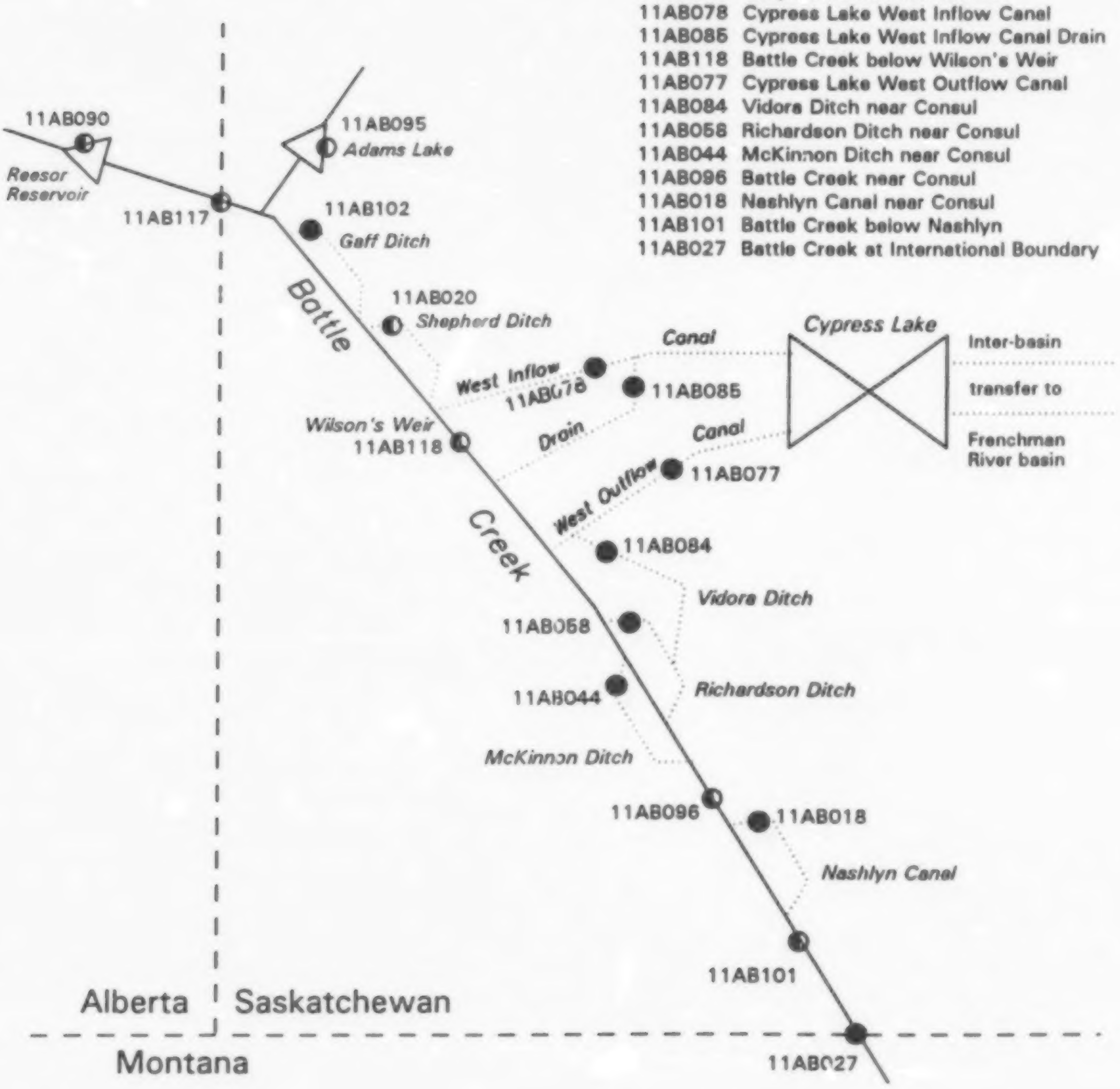
LEGEND

● International Gauging Station

◐ Other gauging station

■ International Reservoir Station

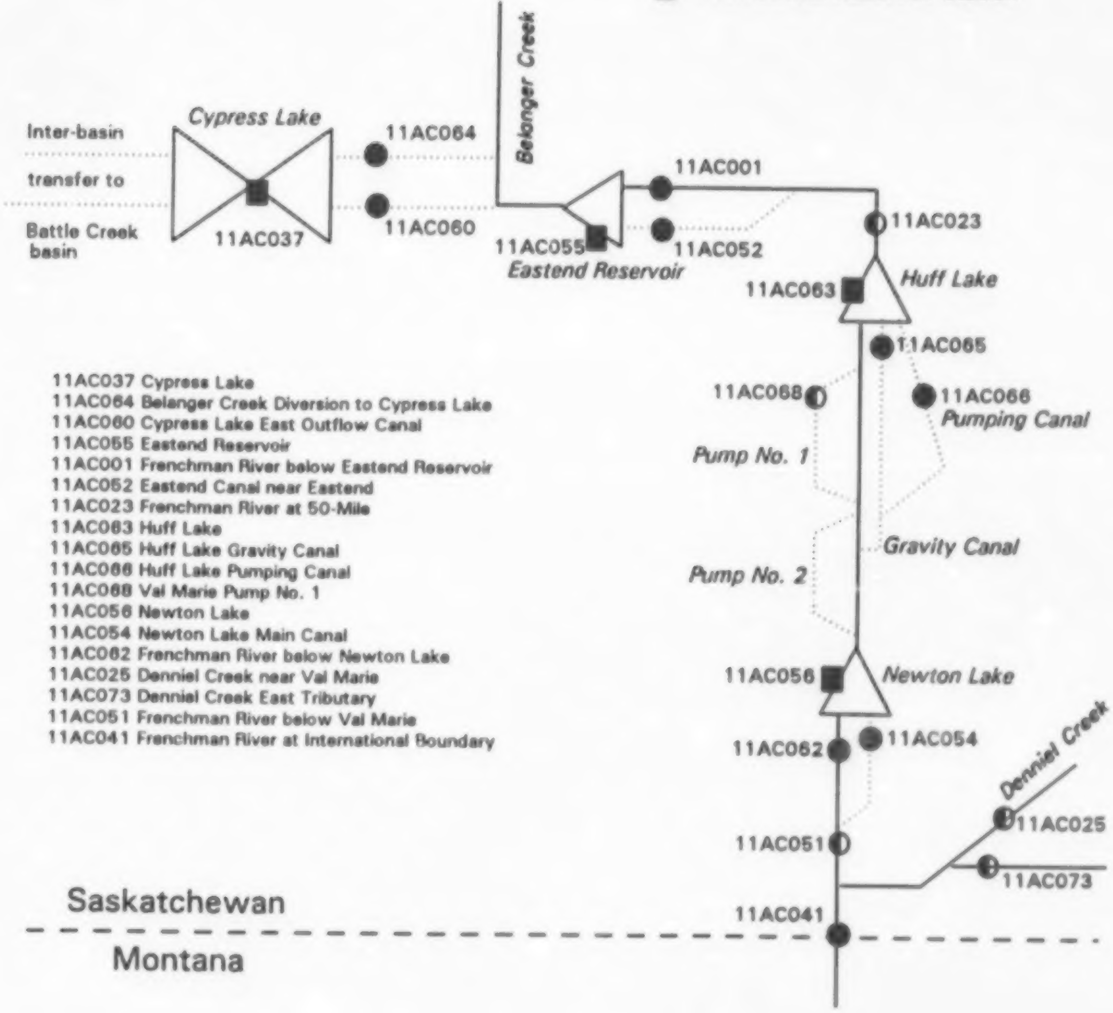
11AB090	Reesor Reservoir near Elkwater
11AB117	Battle Creek at Alberta Boundary
11AB095	Adams Lake
11AB102	Gaff Ditch near Merryflat
11AB020	Shepherd Ditch near Consul
11AB078	Cypress Lake West Inflow Canal
11AB085	Cypress Lake West Inflow Canal Drain
11AB118	Battle Creek below Wilson's Weir
11AB077	Cypress Lake West Outflow Canal
11AB084	Vidora Ditch near Consul
11AB058	Richardson Ditch near Consul
11AB044	McKinnon Ditch near Consul
11AB096	Battle Creek near Consul
11AB018	Nashlyn Canal near Consul
11AB101	Battle Creek below Nashlyn
11AB027	Battle Creek at International Boundary


11AB090
Reesor Reservoir
11AB117
11AB095
Adams Lake
11AB102
Gaff Ditch
Battle Creek
11AB020
Shepherd Ditch
West Inflow Canal
11AB078
11AB085
Drain
Cypress Lake
Inter-basin transfer to Frenchman River basin
Wilson's Weir
11AB118
West Outflow Canal
11AB077
11AB084
Vidora Ditch
11AB058
Richardson Ditch
11AB044
McKinnon Ditch
11AB096
11AB018
Nashlyn Canal
11AB101
Alberta
Saskatchewan
Montana
11AB027

Map 9
Schematic Map
Frenchman River Basin

LEGEND

- ● International Gauging Station
- ◐ Other gauging station
- ■ International Reservoir Station



Belanger Creek
Inter-basin
transfer to
Battle Creek basin
Cypress Lake
11AC037
11AC064
11AC060
11AC001
11AC055
Eastend Reservoir
11AC052
11AC023
11AC063
Huff Lake
11AC065
11AC068
11AC066
Pumping Canal
Pump No. 1
Gravity Canal
Pump No. 2
11AC056
Newton Lake
11AC062
11AC054
Denniel Creek
11AC025
11AC051
11AC073
11AC041
Saskatchewan
Montana

11AC037 Cypress Lake
11AC064 Belanger Creek Diversion to Cypress Lake
11AC060 Cypress Lake East Outflow Canal
11AC055 Eastend Reservoir
11AC001 Frenchman River below Eastend Reservoir
11AC052 Eastend Canal near Eastend
11AC023 Frenchman River at 50-Mile
11AC063 Huff Lake
11AC065 Huff Lake Gravity Canal
11AC066 Huff Lake Pumping Canal
11AC068 Val Marie Pump No. 1
11AC056 Newton Lake
11AC054 Newton Lake Main Canal
11AC062 Frenchman River below Newton Lake
11AC025 Denniel Creek near Val Marie
11AC073 Denniel Creek East Tributary
11AC051 Frenchman River below Val Marie
11AC041 Frenchman River at International Boundary